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REVIEW OF 12-HOUR SHIFTS AT NUCLEAR GENERATING STATIONS

FINAL REPORT

by

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ABSTRACT

This project reviewed the practice of 12-hour shift work schedules at nuclear power plants, and its relationship to safety. The current literature was examined for information on accidents, fatigue and personal preferences. Interviews with operators and maintainers showed that these groups had attitude and preference differences related to both 12-hour shift schedules and overtime work opportunities. Several factors related to 12-hour schedules were identified which could affect safety, but which have not been adequately considered.

RÉSUMÉ

Le présent rapport examine la pratique des quarts de travail de 12 heures dans les centrales nucléaires et leurs répercussions sur la sûreté. Les auteurs ont examiné la documentation actuelle sur les accidents, sur la fatigue et les préférences personnelles. Les entrevues avec les opérateurs et les préposés à la maintenance ont révélé qu'ils avaient des vues différentes à propos des quarts de 12 heures et des possibilités de faire des heures supplémentaires. Plusieurs facteurs qui pourraient nuire à la sûreté, mais qui n'ont pas été considérés convenablement, ont été signalés par rapport aux quarts de 12 heures.

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I LITERATURE REVIEW

As part of this contract recent research on 12 hour shifts was reviewed. There have been few studies in industry comparing 12 hour and 8 hour shifts. There are three reasons for this. First, 12 hour shifts are a fairly recent phenomenon. Second, for practical reasons, an experimental comparison between 12's and 8's in an industrial setting can only occur when there is a changeover between one schedule and the other. Third, changes in performance due to a move from one schedule to another can only be determined by using a test battery to obtain performance measures, or by collecting performance data from the job being performed, e.g. errors in technical log entries, or number of significant events. The former can be intrusive and the latter provides such a gross measure of performance that data must be collected over a long period of time if differences due to shift scheduling are to be detected.

Despite these difficulties there have been two field studies of direct relevance to the nuclear industry. In addition to these, laboratory studies of relevance to 12 hour shift schedules will be reviewed, as well as studies related to the question of overtime on 12 hour shifts. Contacts were made with managers in the petrochemical industry, which has the longest history of use of 12 hour shift schedules. Their experience will be reviewed. Literature on individual differences, including effects of age, in relation to performance and shiftwork will be discussed. Finally, anecdotal evidence from plant managers in nuclear plants on 12's and expert opinion evidence, obtained by contacting numerous experts in the area of shiftwork, will be summarized.

I.1 Experience of 12 Hour Shifts in the Petrochemical Industry

The industry which has the greatest experience of 12-hour shifts appears to be the petrochemical industry, in which case of "12s" can be found going back for more than 15 years. The Wharton School of Industrial Research Unit at the University of Pennsylvania has published a number of reports on this industry, and is currently completing a further study (Wilson and Rose, 1978, and personal communication). Imperial Oil was the leader in implementing "12s", and should be consulted to review what is probably the greatest collection of evidence. Dow Louisiana cited reduced absenteeism, reduced unscheduled overtime, improved operating efficiency, improved maintenance efficiency, improved communication and continuity across shift changes, and improved morale. However, it must be said that really systematic and objective collection of data is rather scanty.

Wilson and Rose give examples of a great variety of shift schedules for "12s", as do Tepas and Monk (1988), and there is no doubt that there is a strong interaction of time on shift and shift schedule. Two findings reported by Wilson and Rose have repeatedly been reported. With "12s" each shift hands over to the same people who handed over to them. This seems to make communications of plant status easier, and it is repeatedly reported that this kind of communications is better than with "8s". On the other hand, almost all "12s" allow people periods of at least 3 days off work fairly frequently, and may include as much as one week in 7 off completely (Tepas and Monk, 1988). This has the opposite effect. The longer periods of absence make the workers forget the details of any abnormal plant status indications, and make them relatively out of touch with the state of

the plant on their return. It is frequently recommended that much more systematic written communication is needed to log the state of the system when people return from a long spell off. Further, where only operators and maintenance personnel, but not management, work shifts, some patterns of shift rotation with "12s" can mean that even a manager who conscientiously tries to keep in touch with his workforce, does not see a particular person on day shift for as long as several weeks. Over what ranks this effect will extend will obviously depend on the particular organization of the plant, but it could have a bad effect on morale, although none such seems to have been reported to date.

I.2 Recent Laboratory Research on 12 Hour Shifts

There have been a number of attempts to carry out experimental studies which are relevant to 12 hour shifts in the nuclear industry. Rosa, Wheeler, Warm and Colligan (1985) developed a test battery to detect fatigue, in which both performance and subjective criteria are used. This battery has been implemented in a form which can be administered by a computer, and Rosa's colleagues have begun to use it in both laboratory and industrial settings. They note that earlier experimental studies contain many confounding factors, including shift patterns and personality differences. In their experimental study, 6 males worked at a "realistic" key punching data entry task for 8 hour or 12 hour shifts over a period of 48 hours. They were given three subjective scales for reporting feelings of fatigue, the Yoshitake Fatigue Symptom list, the Stanford Sleepiness Scale, and Activation Adjective Check List. Every few hours they also stopped their main task, and took a battery of performance tests, based on standard laboratory tasks for investigating the efficiency of human information processing. These included grammatical reasoning, digit addition, serial verbal memory tasks, time estimation, auditory reaction time, choice reaction time to visually presented verbal stimuli, auditory acuity tests, synchronized tapping, hand steadiness, and simultaneous tests of grammatical reasoning and auditory reaction time.

Because the number of participants was so small, the levels of statistical significance were not high, but the following effects appear to have been present. On the main task (data entry) there were very small but just statistically significant increases in errors and decreases in speed for the 12 hour shift compared with the 8 hour shift. By the end of the day correct entries were 159 per ten minutes compared to 168, and errors rose to 16 compared to 13. There was a greater improvement with practice on the 8 hour per day for 6 days condition than on the 12 hours a day for 4 days condition. But the differences were very small and not reliable. Towards the end of the 12 hour shifts, performance on the grammatical reasoning test and the arithmetic test showed very slight decreases, and the self ratings of fatigue showed slight increases. In fact, the latter actually showed increased performance towards the end of the shift. The authors conclude that there are some measurable signs of increased fatigue and decreased performance towards the end of the 12 hour shift. But they also warn that the scope of their study was such as to need far more data before firm conclusions can be drawn to the effect that 12 hour shifts are undesirable.

Rosa and Colligan (1988) conducted another study to validate the use of the test battery. Their participants practiced the data entry task for 5 12-hour days each time from 0700-1900 hr. They then rested 2 days at home, and during a third

rest day took the test battery at the laboratory, then worked at the laboratory for 5 12-hour days, had a further two days' rest, and once more had another day's rest during which they took the test battery at the laboratory. The test battery was also given during their working days. Rosa and Colligan analyzed their data for effects of time of day, day of the week, and their interaction. The effects were very small, and indeed the test battery performance was, overall, better on workdays than on rest days, which may have been due to levels of arousal.

I.3 Research on 12 Hour Shifts in Process Control

Only two studies were found which examined performance over a 12-hour shift in process control plants. Both examined performance on a test battery over the course of 12-hour shifts; in addition, one examined errors in completing logs and numbers of significant events.

The first study, which is probably the most thorough and systematic study of direct relevance to the nuclear industry is that by Lewis, Swaim, Rosa, Colligan, Booth and Swint (1986). This report should be read in its entirety by anyone making a decision about 12-hour shifts in the nuclear industry. Before quoting some of its findings, several points should be noted. (The authors themselves point out these caveats.) Firstly, the study was of only one facility, the Fast Flux Test Facility at Hansford. Secondly, the workforce interviewed was all under 35 years old. A variety of measures were used, including the quality of plant logs, frequency of incidents, interviews, health of personnel, subjective opinion, and actuarial data on turnover of plant personnel. As a result of the schedule change, plant performance improved in two ways. The operator error rate in keeping the Technical Specification Compliance Logs which was already very low on the 8-hour shift, was even lower on the 12-hour shift. Also, operator interface with maintenance resulted in an increase in the productivity of maintenance personnel. The number and severity of off-normal events was not affected by the schedule change.

Although the evidence on operator alertness was contradictory, the bulk of the evidence from a variety of sources, including computerized tests of alertness, indicated that most operators were generally somewhat more fatigued on the 12-hour shift. However, as mentioned above, this did not result in a statistically measurable change in plant performance. The conclusion of Lewis et al was that there were no good reasons to object to 12-hour shifts <u>on the basis of their evidence</u>. They note, however, that some 16% opposed the plan, 39% said their sleep was worse, and two single parents left the plant because their lives became too difficult. There were no age differences, but as pointed out, there were no workers over 35. The authors suggest that older workers might find the regime harder. They point out that a long commute time at the end of a long shift could be difficult, but that because of the structure of the shift schedule, it would be done less frequently. The planning of the overall shift scheduling is at least as important as the length of the shift itself. Overall, the picture given by this very thorough study is that the effects of 12-hour shifts are complex, subtle, difficult to ascertain, and difficult to optimize. But there is no evidence for the 12 hour shift schedule,which they examined, being harmful to safety or performance.

In the second study, Rosa, Colligan and Lewis (1988) administered the same test battery described in Section I.2 to workers on site at a process control plant. The work consisted mainly of control panel and computer monitoring. There were 52 workers on 8-hour shifts, and 55 on 12-hour shifts. Twenty four experienced both kinds of shifts, of whom 21 were male. There were 20 between the ages of 25-34, and all the rest were older. No practice on the test battery could be given, and different workers received it at different times, so that sampling was (inadvertently) random around the clock. Data were collected on the last 5 weeks of the 8-hour shift and the first 5 weeks of the 12 when they changed. Finally, more data were collected for 10 weeks after the 12-hour shift had been in place for 7 months. Practice effects, etc., were statistically controlled by multiple regression techniques.

The results showed that there were measurable effects on test battery performance due to type of shift schedule, time on shift, circadian rhythms, and an interaction of time on shift with circadian rhythms. There were no significant effects of number of consecutive days worked, amount of sleep, or time since waking. (The first of these could be evidence against the build-up of cumulative fatigue on "12s"). The strongest effect was that the regression equation predicted a 187% increase in errors on the reasoning task when comparing the "8" to the "12" shifts. But it should be noted that the absolute magnitude of the change was <u>extremely</u> small - 1.33 errors per ten minutes. Subjective sleepiness increased on day shifts by 27% after 8 hours, and by 41% after 12 hours compared with the start of shift; and on night shift the figures were 42% and 66%. the most significant changes in self-reported stress was on the 4th to the 6th days of shift work. The authors comment that,

> "In no case did the 12-hour schedule result in better performance/alertness scores. Thus the extra worktime per day seems to be a major factor producing poorer scores during the 12-hour schedule."

On the other hand, there were considerable improvements on the test battery scores with experience, and none such were apparent for the 8-hour data. Above all, there was no change in the plant performance, that is, in the quality and productivity of process control.

The conclusions which one can draw from the work of Rosa and his colleagues thus seem to be as follows. There are at least some detectable changes in the quality of human information processing at the end of 12-hour, compared with 8-hour shifts. However, they are slight, and their meaning in terms of the "real" task which the workers are employed to perform is obscure, since changes in "real task" performance is slight or negligible. One cannot conclude from Rosa's work that there is cause for worry about a deleterious effect on real industrial tasks for 12 hour shifts.

I.4 Overtime and 12-Hour Shifts

There have been many studies on the effects of extended hours of work on various tasks. The Ontario Hydro literature review on 12 hour shifts references numerous studies showing performance deterioration increases between the 8th and 12th hour of working. A number of studies have examined very extended periods of work and

have shown noticeable decrements beyond the 12 hour point. Morgan, Brown, and Alluisi, 1974, used a test battery developed by Alluisi and found that performance decrement set in after about 18 hours. It is important to note that the Alluisi task battery is quite realistic, and involves the operators living in the experimental setting for the entire duration of the task, with occasional breaks for food, toilet, etc. Furthermore the battery includes both perceptual-motor skill components and also cognitive tasks of a puzzle-solving variety. Thus cognitive abilities were tested. The results of this study support the claim that 12 hours is acceptable, but also certainly supports the claim that significant extensions beyond 12 hours, for example as might be experienced due to overtime, would lead to the region where significant measurable quantitative declines in performance can be detected.

The data from the experiments of Alluisi and his colleagues are some of the most "realistic" laboratory studies to examine the effects of prolonged work. But it must be remembered that the work period was one very prolonged session, and that the personnel were military people performing laboratory versions of military tasks. For more realistic data we must probably wait for experiments from such facilities as the new Institute for Circadian Physiology (Moore-Ede, 1988).

In relation to low levels of mental workload, Hamelin (1987) for example, found that the risk of being involved in an accident among truck drivers rose sharply after about 12 hours driving. Like the task of the first operator, truck driving requires extended periods of monitoring. In relation to high levels of mental workload, Mullaney et al.(1983) required subjects to work at 4 tasks, repeated every 10 minutes for 42 hours. Serious performance and psychological changes occurred after 18 hours.

The findings on extended hours of work serve to draw attention to a point made by several authors with regard to "12s". One must always remember that a 12-hour shift is nominally a 12-hour shift. One must add on the time for commuting. Driving after a 12 hour night shift is likely to be risky. Moreover, there is a widespread informal opinion among people who have studied shift work, although again it is not backed up by hard data, except for data such as Hamelin's and Mullaney's, that a serious problem would be overtime. Overtime on top of a 12-hour shift would push people into the region where what evidence there is suggests that fatigue and deterioration of performance, begin to set in rapidly. It is a matter of "expert opinion" that if a 12-hour shift is adopted, there should be very stringent rules preventing overtime on top of the 12 hours. But data, in the form of accident or incident reports from the process industries, appears to be absent, either to support or to refute the case.

I.5 Age Effects and Shiftwork

There are some indications from experimental human factors studies that suggest that older workers are likely to find 12 hour shifts more of a problem than younger workers. These studies are not specifically on 12-hour shifts, but are more concerned with age differences in response to shift work as such, or in response to very prolonged work sessions in which cumulative fatigue built up over several days. For example Akersted (1976) and Akersted and Torsvall (1981) claim that, when they examined workers more than 45 years old, the older the worker (among those over 45) the more likely they were to complain about this. In

addition, separate from age, there were more frequent complaints amongst those who had worked at shiftwork longer.

There is considerable agreement that physically demanding long shifts will have a worse affect on older workers. Indeed this must of necessity be so as the physical endurance of elderly people is less than that of the young. The problem is that in considering an industry like the nuclear industry, it is not the physically demanding jobs which usually are thought of as raising the greater concern. It may be than certain aspects of maintenance would fall into the class of physically demanding jobs, and hence might be hard on the older workers. But it would not be too difficult to arrange task allocation in such a way as to reduce the exposure of the elderly to such tasks as induce greater physical fatigue. For tasks which are not physically demanding, the data are as discussed earlier.

I.6 Individual Differences and Shiftwork

The search for "individual differences", that is, personality differences, in response to long shifts and long sustained work periods has led to mixed results. Cameron (1973) for example, believes that there are such big individual differences in the way people respond to work situations that it is impossible to specify conditions which are inherently fatiguing to all people. Morgan, Winne, and Dugan (1980) used the test battery developed by Alluisi during shifts of 36-42 hours continuous work. Later on in the work period, when they looked at the performance of people across successive 2-hour periods, they found stable patterns of differences. But the duration of work here is far in excess of the with which this report is concerned, and the differences were not great enough anyway to do more than suggest that there was something to be investigated further.

There are a few other studies which hint at personality variables such as the neuroticism or introversion dimensions of Eysenck, but the evidence is weak. Likewise there are some studies which suggest that some people may choose night shifts, but these are from rather special jobs such as nursing, and their relevance to nuclear operations is unclear, as well as the magnitude of the effects being weak.

I.7 Anecdotal and Expert Opinion Evidence

In preparing this section of the report Rosa, Tepas, Colquhoun, and Moore-Ede, all experts on shiftwork, were consulted. All gave similar comments, to the effect that there was very little objective data indeed to support strong statements about industrial work. It simply does not appear at present that there is any objective data, in the form of performance logs, to suggest that 12-hour shifts are unsafe. Moore-Ede and his group are in the process of acquiring a simulation facility in which to conduct prolonged studies on shifts, sleep, and work, and that effort should be carefully monitored. No one was aware of any work, either in North America or Europe, which was in progress or completed which could throw clear light on the problem. All spoke of the problems of overtime, moonlighting, etc. All had found that by and large the workforce were almost always in favor of "12s". There were some hints that older workers, over 40 to 50 years, might find them less acceptable. But it seems likely, on the present evidence, that with 3-shift working being so unpopular, and there being so many cases where bad shift rotation schedules have been adopted, or management have

shown indifference or worse for workers' complaints, that a well-planned 12-hour schedule, with appropriate time off, carefully designed logging procedures and communications, etc., will an many cases be in improvement.

Colligan and Tepas (1986) report that there is an increasing tendency for industry to go to "12s". They report anecdotal evidence by workers who have experienced both to the effect that "12s" are believed to produce fatigue which decreases performance. This is interesting in that workers were prepared to state this although they prefer "12s". But again, there was no data, in the form of accident reports or changes in productivity, to back it up. Their work does raise another often repeated worry: they found that 25% of workers on "12s" were moonlighting, that is, had a second job. This is worrying in that it suggests that workers on "12s" may be less well rested than one would conclude from the official shift schedule. On the other hand, one repeatedly comes back to the fact that there is no objective evidence of increased hazard.

Perhaps the most interesting anecdotal evidence came from a conversation which we had with a member of the management of the Nuclear Power Division of Duke Power, Inc., who kindly spoke to us about their experience (Hampton, 1988). About seven years ago, Duke decided to implement "12s" when a new and advanced fossil fuel station was started up. The first year's experience was so successful, that the management then implemented "12s" at all their fossil stations, and then at their nuclear stations. They have cooperated with the NRC in keeping a trace of incidents, etc. in all their plants, and have found no evidence of any deleterious effects. The manager we spoke to confirmed the opinion of managers in the petrochemical industry that a changeover from one crew to another and back again was definitely an improvement over changing to a different crew each time as occurs with 3 eight hour shifts. Duke's pattern is usually 3 days on (sometimes 4) followed by 2 days off. Every tenth week they have 7 days off. The hours are 0700-1900 and 1900-0700. Duke has put its entire shift work population on "12s", not just their operators, and the only people who seem dissatisfied are mothers with young children, who have the problem of leaving the children with day-care or school prior to 7 am, and being unable to see them again until after 7 pm (Similar problems were noted by single parents at the Fast Flux Test Facility at Hansford). The Duke manager stated that they have not had any complaints from older workers, which is somewhat surprising in light of the human factors studies reported earlier.

It seems that in the power industry this may be the most extended experience yet of "12s", and it is recommended that Duke's experience be followed closely. Because of the company's excellent record of research and development, including a serious understanding of and commitment to human factors in general, it is likely that if there are data to be logged about "12s", they may be found here. (A problem is, of course, that deleterious effects, if they exist, may turn up first at companies which are not as well managed as Duke Power.)

Moore-Ede (1988) quotes a number of findings which are clearly of relevance to the effects of prolonged shift work on health, accidents, and human error. He also quotes a case where adopting a bio-compatible shift schedule increased productivity by 32%, indicating that, as we have stated, it is incorrect to think of the resolution of shift problems as being only of relevance to health and safety. A correct shift plan is also of direct relevance to profitability, and

the choice of a good shift plan is of benefit both to management and to the workforce.

I.8 Summary

The findings of work on 12-hour shifts can be summarized quite succinctly. There is evidence of increased fatigue, providing subtle measures are used to test for it. There is no evidence for an increase in accident or incident rates. The majority of workers prefer the "compressed work week" of the 12-hour shift to the conventional 8-hour shift, although a few special cases have been reported of people who do not like it. These are the best established findings: there is a considerable amount of anecdotal and suggestive evidence in addition. In particular, it is very important to consider not merely shift length, but the pattern of shift rotation and days off, and the question of overtime, as all these can affect subjective fatigue and performance.

II REVIEW OF MATERIAL LEADING TO AECB CONFIRMATION OF 12 HOUR SHIFTS

The material reviewed under this contract which led to AECB's decision to confirm the use of 12-hour shifts for Ontario Hydro generating stations included the following:

1. Ontario Hydro Reports:

a) Assessment of the Impact of 12 Hour Shifts on the Nuclear Control Room Shift Crew Performance, Dec. 1981

b) Analysis of Human Errors at Pickering A, 1978 - 81, Dec. 1981

c) Analysis of the Impact of 12 Hour Shifts on Human Performance at Ontario Hydro Nuclear Generating Stations (four volumes covering the period June 1985 through April 1986)

2. Correspondence between the AECB and Ontario Hydro on the subject on 12 hour shifts and limitations on overtime for the same.

The first report is an analysis of the literature on the effects of extended hours of work, the effects of time of day and the effects of circadian upset on performance. The analysis clearly supported the view that 12 hour shifts would result in a greater risk of error in all aspects of the nuclear operators task. **In fact a doubling of human errors on 12 hour shifts compared to 8 hour shifts was predicted.** The second report is an analysis of human errors by operating personnel, carried out prior to the implementation of 12 hour shifts at Ontario Hydro nuclear stations. The report examined the relationship between human errors and various aspects of shift-working. These aspects included time on shift, day in shift sequence and age. Trends in the data were determined but no statistical tests were made to determine which, if any, changes were significant. Once the 12 hour shifts were introduced at Ontario Hydro nuclear stations a monitoring program was put in place to compare various health, safety and productivity indices in the two years prior to the introduction of 12 hour shifts with the year following. The results of this program were reported quarterly, starting June 1985 and finishing April 1986. These four volumes comprise the third report.

Contrary to the results of the literature review, the reports which deal with actual changes in performance at the nuclear generating stations show no trend towards increased error rate with time on shift nor any significant increase in error rate as a result of the change from 8 hour shifts to 12 hour shifts. The reasons for the apparent discrepancy between research findings and actual results will now be discussed. Most of the comments below are directed towards the third report since it attempts a statistical comparison (as opposed to an examination of trends only as in the second report) between 8 hour and 12 hour human error rates.

II.1 Criterion Measures

Changes in health, safety and productivity due to the introduction of 12 hour shifts were assessed by using a variety of different measures, e.g. number of Type A or B process system faults, employee sick time, number of fuel bundles loaded. However due to the nature of the measures available, changes in safety could only be assessed very crudely. Of a total of 885 operators employed during the 2 year period prior to the introduction of 12 hour shifts, the average number of operators committing reportable errors in any one quarter was 21.875, with operators committing errors per quarter varying from a low of 19 to a high of 30. After the introduction of 12 hour shifts the average number of operators committing errors in any one quarter was 23.75 with a range of 14 to 32. Similarly there were few reportable errors amongst mechanical maintainers or control technicians, and a great deal of variability from one quarter to the next in terms of the number of errors reported. It is difficult to assess changes due to shift schedule on the basis of so few errors.

The fact that the major (in that they were reportable) errors were so few both before and after the shift schedule change is commendable and a sign that the current shift system is, in general terms, acceptable. However, if one wishes to determine whether the *risk* of a serious accident has been increased due to the introduction of 12 hour shifts, these measures are not sufficient.

To give an example, imagine two groups of drivers. One group drives just above the legal limit for alcohol every night of the year; the other group drives in a sober condition. On average, in Ontario, the risk of an accident is 0.055 accidents per year with a standard deviation of 0.055 accidents per year. Thus one would expect the number of accidents reported for a year period in a group of 1000 drivers to vary between 0 and 165.

From studies which use a data base of thousands of accidents, we know that the risk of driving at the legal limit is in fact double that of driving in a sober condition. However, if one examines as few as 1000 drivers in each group, the standard deviation of the estimate of accident risk is so large that it would be quite within the realm of statistical probability for the groups to have the same number of accidents, say 65 each, in the year in which we happen to collect these data. For the sober drivers, 65 would be a little more than the expected average of 55 but still well within the expected range. For the drunk drivers 65 would be lower than the expected average, but again, still in the expected range. If we had only these data on which to base our conclusion about the risk of driving after consuming more than the legal limit of alcohol, we might conclude that the presence of alcohol does not increase the risk of an accident. However, data ob-

tained from much larger samples of drivers shows that such a conclusion would be wrong.

Accidents, fortunately, are so rare that 1000 drivers have very few. To determine the change in the risk of an accident while driving drunk, one needs data from many more drivers or one needs to take detailed samples of driving behaviour, e.g. lane position variability over a fifteen minute period for 20 or so drivers in a sober condition and after consuming alcohol. It is only by using more accident data or detailed behavioral data that one can establish that the true risk of an accident while driving just above the legal limit is in fact much higher than that of driving in a sober condition.

Applying this to the situation at hand, the monitoring reports, for the June 1985 to April 1986 period, show, for example, that an operator can be expected to make one reportable error approximately every 10 years. This estimate is only slightly higher for the 12 hour shifts compared to the 8's. It is recognized that the authors of the monitoring report used all the data on reportable human errors available to them at that time. However, the comparison of 2 years worth of such data on 8 hour shifts with 1 years worth of data on 12's is insufficient to determine whether the risk of an accident due to human error has increased.

The above would be true even in the ideal situation where the fluctuation in error rates is only due to the random nature of errors and accidents. In the situation under consideration, over a period of several years, there are other factors which affect error rates: the occurrence of shut downs, changes in operating personnel and strikes. This adds even more uncertainty to the calculation of changes in error rates. In fact, it is possible to make an estimate of the smallest increase in risk that would be detectable with baseline data on 8's being limited to 2 years and with the assumption that one has the best situation where the only factor affecting error rates is natural variation. This is as follows. At the 95% level of confidence the confidence interval for the estimate of error for 8 hour shifts is 40.75 + 7.97 errors per quarter. That is, one can be confident that the real error rate for 8 hour shifts lies between 32.78 and 48.72 errors per quarter. If one had an infinite number of years of data on 12 hour shifts, the smallest increase in error rate that would be detectable, comparing a two year period of 8 hour shifts with an infinite period of 12 hour shifts, would a be a 20% change, that is, an increase from a mean of 40.75 errors per quarter to a rate of 48.72 errors per quarter. A change in error rate of less than this amount would not be detectable at the 95% level of confidence. If there are fewer than an infinite number of years of 12 hour shift data, then the increase in error rate would have to be even higher than 20% to be statistically detectable.

The above calculations were made using the assumption that the only factor affecting error rates is natural variation. However, we know this is not the case. In fact, the report on error rates at Pickering showed that in the 3.75 year period over which human error data were examined, human error rates during shutdowns were 4 **times** as high as human error rates under normal operating conditions. This is of interest because outages were considerably higher for both Bruce and Pickering NGD during the 1 year period when 12 hour shift error rates were examined as compared to the 2 year baseline period when 8 hour shifts were worked. The fact that these outages result in higher human error rates was not taken into account in the comparison of 8 hour and 12 hour shift error rates.

The limitations of using a base period of 2 years of 8 hour data combined with the fact that error rates are affected by other factors besides random variation means that conclusions based on these data about changes in error rate are unreliable.

At this point, because of practical considerations, one cannot go back to an 8 hour schedule merely to collect data for comparison purposes. One could however attempt to assess whether performance declines and fatigue increases: 1) over the shift period of 12 hours and 2) over the shift cycle of 35 days. Such an assessment would be useful for determining the least fatiguing 12 hour shift schedule as well as for determining changes with age. The appropriateness and manner of conducting such an assessment will be discussed in section V.2.

II.2 Error Rate Breakdown by Time

Both Ontario Hydro reports which analyzed human errors at nuclear stations attempted to determine whether or not errors increased with time on shift. The first report, which analyzed errors at Pickering NGD, did not find any trend towards an increase in error rate over an 8 hour shift. The second report attempted to assess whether or not workers became more fatigued at the end of the shift when they worked 12 hours as compared to 8 hours. The percent error distribution, in 2 hour intervals, was calculated. In both reports the result of the analysis was to show no increase in errors towards the end of the shift.

The first problem in doing this is the same as that discussed above: insufficient data. Dividing the few reportable errors up further into 1 or even 2 hour segments means there is even less chance of being able to measune an effect, here differences between time periods.

The second problem in looking at error rate by time is that the basis for the comparison between time periods is missing. Without knowing how many control actions are carried out in the different time periods, it is difficult to either compare 8 and 12 hour shifts or to compare time periods within a shift. It is likely that work is organized differently on 12 hour shifts compared to 8 hour shifts. On the 8 hour schedule the monitoring report showed that errors, for all personnel combined, are fairly evenly distributed across the morning shift (8am to 4pm), which is the busiest shift. During the other two shifts, errors peak in the first 2 hours, which would lead one to suspect that work was organized so that more control actions were carried out in the first 2 hours than during other time periods. For the 12 hour shifts, the highest error rate occurs during the second 2 hour period. Since these shifts are longer it may be that workers arrange their work differently so that there are more control actions in the second 2 hour period, still near the beginning of the shift but a little later than was the case for the 8's. Without any hard data on number of control actions per hour, this is all speculation. However it should be clear that without these data any conclusions about the effects of shift length on error rates are premature.

II.3 Overtime and Errors

To assess the connection between overtime hours and errors the work schedule of the person committing the error was examined for the two weeks prior to the er-

ror. Exceptional overtime was considered to be more than 3 night shifts in a row, more than 60 hours in a fiscal week or more than 14 hours in a day. Any errors occurring to people who had worked exceptional overtime were documented. Each of the quarterly monitoring reports documents such errors and the final report provides a summary of all exceptional overtime worked in the fourth quarter of the monitoring program. In general, the conclusion of the report was that the only concern related to overtime and 12 hour shifts arose from an increase in mechanical maintainer accident frequency across NGD. The authors suggest that this increase was related to overtime working associated with unit outages.

To assess the connection between overtime and errors it is important to know not only how many errors were committed by personnel working overtime (as given in the monitoring report), but also the percent of total person-hours worked which were overtime hours. To give an example, if 50% of total operator-hours was worked by operators working overtime and 50% of the errors were made by operators working overtime, there would be no evidence that overtime had anything to do with increased error risk. On the other hand, if 25% of total operator-hours was worked by operators working overtime and 50% of the errors were made by these operators, then there would be evidence that overtime increases the risk of error.

A second comment on the monitoring report's assessment of overtime is that the criterion for overtime is rather high. A number of studies have shown increases in sickness and decreases in productivity to occur after 40 - 44 hours per week are worked. A better cut-off point would have been to examine errors occurring to operators who had worked more than 48 hours in a 7 day period. An additional problem is the use of the fiscal week in defining overtime. Fatigue due to overtime does not cease at the end of the fiscal week in which the overtime is worked. When information is collected on overtime, the previous 7-14 day period should be considered, regardless of where the fiscal week starts or stops.

One final point is that in future errors might be assessed in terms of the shift they occurred within the shift sequence as was done in the December 1981 report on human error at Pickering NGD. As will be discussed in section IV of this report, the 3 midnights in a row followed by 48 hours off before the first day shift is a very fatiguing part of the schedule. One would expect that errors are more likely to occur here than at other times. Given the fact, according to this same December 1981 report, that error rates during shut downs are 4 times as prevalent as errors during normal operating conditions, operating conditions at the time of the error need to be taken into account in the analysis.

III INTERVIEW RESULTS

As part of the evaluation of 12 hour shifts, shiftworkers who were supervisory personnel, operators, maintenance workers and control technicians were interviewed. In total 8 first operators, 1 second operator, 4 shift supervisors, 2 shift operating supervisors, 6 mechanical maintainers, 7 control technicians and 6 supervisors of maintenance personnel were interviewed. Personnel were interviewed on an individual basis for a period of 30 to 45 minutes. Samples of the questionnaires used, one for the control room personnel, and one for the maintenance personnel, are shown in Appendix A. Each interviewee was assured that his answers would be confidential and that the report would not identify individuals making particular comments.

The interviews were not intended to provide statistical data on which to base decisions. Far too few individuals were interviewed than would be necessary to obtain a statistically sufficient sample. Instead the interviews were intended to be open ended in nature so that areas of concern with respect to 12 hour shifts not yet identified through Ontario Hydro reports reviewed earlier or through our review of the literature, could be determined. Also the interviews were used to test possible reaction to changes in the shift schedule which, according to our understanding of circadian effects, should reduce fatigue. Sometimes there was extended discussion of one or other item with particular individuals and as a result not all individuals were asked all questions. In some cases it became quickly obvious that a question was always going to be answered in a particular way, so that if time was short, these questions were not asked. Details of the answers to each question are given in Appendix B for three groups: operators, control room supervisors, and maintenance personnel.

III.1 Summary of Operator Interviews

More operators preferred the 12 hour schedule than the 8. They also estimated that a minority of their colleagues, between 20 and 40%, would want to return to 8's. Operators judged that the characteristics of those operators who preferred 8's were that they were older or had school age children or preferred to be able to work and participate in leisure activities on any given work day rather than devote entire days to work or to leisure.

Operators said that work on the 12 hour shifts was organized differently from work on the 8's. Two sets of system safety tests were done on the 12 hour day shift and one set on the 12 hour night shift. On the 8 hour shift system one set of safety tests had been done on each shift. Also there was an extra maintenance crew on during the day shift. These two factors made the day shift busier than the night shift.

Discussions with the operators indicated turnover time does not exceed 15 minutes per shift very often. Occasionally, when large changes in plant status had occurred, operators came in an hour early.

The main reason given for working overtime was staff shortages, and in particular the need to cover someone else's vacation if you were going to take your own. Operators noted that the amount of overtime they had to work had been reduced substantially in the last year due to the addition of more licensed operators (Unfortunately, only first operators and not assistant operators were interviewed. From the data on overtime provided by Bruce NGD health resources, this latter group appears to still be working large amounts of overtime.). A number of operators commented on the need to have more than the AECB required minimum of 4 licensed first operators per shift. Those who raised this issue felt 6 would be an appropriate number, particularly considering the increased 'locking up' of supernumary days with requalification requirements. According to the operators, most overtime worked is planned overtime; occasions where an operator is called in unexpectedly are rare. In fact, operators commented that they were very reluctant to take sick leave because they knew a colleague would have to be called in unexpectedly. In terms of ever feeling pressured to work overtime when they didn't want to, operators said they felt no such pressure from supervisory staff.

If they felt any pressure, it was self-generated. Operators were asked how frequently they traded shifts with others. This appeared to be a very infrequent practice.

Working more than 12 hours continuously appeared to happen infrequently. Operators commented that working 16 hours in a row had been far more common on the 8 hour schedule when double shifts were worked. When overtime was worked, the 60 hour rule per week maximum was adhered to. (Again, it must be noted that while this is true for first operators, data from Bruce NGD shows that for assistant operators this 60 hour rule is regularly violated.) However, the 48 hours off between the end of a midnight shift and the start of a day shift found in the regular schedule was occasionally shortened to 24 hours when overtime was worked. The reason for this appears to be that when an overtime night shift must be worked, the tendency is to ask someone who has already worked 3 and is partially adapted to nights, rather than someone who has finished a sequence of days, or is in the middle of a block of days off.

When operators were asked for ways in which the shift schedule might be improved, half of them suggested reducing the number of hours worked to 35. They pointed out that administrative staff who worked days work 35 hours a week and they don't have to spend a significant amount of their time off recovering from time changes. Half of the operators said the requirement to make turnovers so frequently was difficult and they would like to work 4 midnights in a row, since by the time one has worked 3 midnights one has become adapted anyway. When asked how many of their fellows would prefer 4 midnights in a row and how many would want this reduced to 2 midnights, estimates varied widely. In terms of which feature of the current schedule they would most like to retain, the most frequently mentioned feature was the 3 weekends out of 5 free. The response to the suggestion of increasing time for recovery after the 3 night sequence was generally positive, although there was concern that such a change would result in problems somewhere else in the schedule. A number of operators mentioned the difficulty of starting the 35 day cycle, after time off, on a Monday day shift, which tended to be very busy. The workload at this time made it more difficult to get up to speed on changes in plant status as quickly as they would like. Operators who mentioned this responded positively to the suggestion that the first shift back after a long stretch of time off should be a night shift, where more time would be available for catching up on plant changes.

The majority of operators said that there had been occasions, especially on the night shift, where they themselves or others had been seen to nod off very briefly. They emphasized that this did not mean there were occasions where operators were sound asleep in the control room, but rather operators were known to occasionally close their eyes for a few minutes. When asked if it would be possible to organize the work so that a short nap would be possible on the night shift, they said it would be possible. Techniques used to keep awake were taking walks around the plant if possible, using the exercise room, drinking coffee, and in one of the plants, listening to the radio. Operators were satisfied that the frequency and length of breaks they were allowed to take was adequate.

When asked about the effects of working longer shifts on their health, half of those asked thought there had been no effects while the other half thought there were some. The comment was made that if you felt unwell at the beginning of a 12

hour shift you were in worse shape at the end of the shift than you would have been on the 8 hour shift.

Operators were asked if they were aware of more people having second jobs since the introduction of 12 hour shifts. It was indicated by the interviewer that a "second job" included such jobs as being a self-employed tradesman on a part-time basis. No change had been noted in the number of operators having second jobs after the introduction of the 12 hour shift schedule.

At the end of the interviews operators were asked for any additional comments they might have on how their ability to cope with 12 hour shifts could be improved. Some of their comments have already been incorporated into the foregoing paragraphs. Besides these operators noted the following. Comments were made on the difficulty of keeping up with required reading. During day shifts one's concentration on technical material was constantly being interrupted while on the night shift, fatigue made it difficult to concentrate. Operators felt that work should be deliberately organized so that complex jobs were not carried out at night and particularly not towards the end of the night shift when people were at a low point. It was felt that the fact of a physiological low point should be recognized in contrast to the current policy of 24 hour operation.

A number of operators expressed the feeling that the shiftworkers were treated as "second-class " workers and cited numerous examples: the lack of appreciation by day time personnel that a significant portion of their " time off" was compromised by fatigue due to shift changes adjustments; the lack of extra sick leave days in recognition that shift workers are statistically more likely to get sick than administrative staff who work days, simply because of the continual adjustments to time changes, and a number of petty irritants such as difficulty obtaining one's paycheque at nights on a holiday, closure of gates at night which results in a longer drive to the plant, and no early layoff for shiftworkers who could take it at Christmas time.

III.2 Summary of Control Room Supervisor Interviews

Responses to the questionnaire by the 5 control room supervisors interviewed were similar in most respects to those of the operators summarized above. However, they did offer a number of new insights which are summarized below.

In responses to the question about which characteristics distinguished between those who preferred 8 hour and those who preferred 12 hour shifts, 4 out of 5 supervisors identified the main factor as the level of responsibility, that is, the greater the responsibility, the greater the preference for 8 hour shifts. For supervisors and for first operators, 12 hours was felt to require too much mental energy during outages. For first operators during normal operation, 12 hours was felt to be long and boring.

In response to questions about the organization of work, one supervisor commented that managers try not to hand out complex jobs after 4:00 am because they felt there were likely to be more errors made.

In response to questions about overtime, the consensus was that there were few occasions when more than 12 hours in a row were worked. However, one supervisor

noted that technical people from head office were known to work as many as 20 hours straight and construction crews worked for 12 hours running for many consecutive days.

Like the operators, most supervisors felt there should be 6, rather than the current AECB requirement of 4, licensed first operators per shift. One supervisor suggested that with 6 licensed operators per shift, 2 could be put on simulator training for requalification. During this regular requalification, the operators could have a 'normal' life (i.e. day shifts) for 3 months in a year.

All 5 supervisors had experienced having less than 48 hours off at the end of a night shift before the start of a day shift. The comment was made that it was difficult to arrange coverage without breaking the 60 hour per week rule or without having less than 48 hours off between shifts. When coverage is needed for a night shift, the operator generally called in is one who has just finished 2 or 3 nights, and is somewhat adapted to nights. Since there is only 48 hours off in the regular schedule after most night sequences, overtime results in less than 48 hours off before the next day shift. Supervisors, like operators, said that trading shifts was infrequent, but when it occurred personnel were required to check with their supervisor to ensure the 60 hours per week was not exceeded.

In response to the question about breaks, supervisors indicated that they were not rigid in applying rules about official breaks and that the number of breaks people took varied a great deal from one individual to another.

III.3 Summary of Maintenance and Control Technician Interviews

The findings of the interviews with 17 maintenance mechanics, control technicians and supervisory personnel can be summarized as follows. This group were more strongly in favour of 12 hour shifts than were the operators, and they also consistently estimated that their colleagues were similarly in favour. A number of people mentioned improved job satisfaction on 12 hour shifts as a reason for their preference for 12's. Since many maintenance jobs last for long periods of time, a greater proportion of the shift could be devoted to the work compared to the time required to obtain work protection, set up the job, write up reports and clean up on 12 hour shifts as compared to 8's. Also it was more likely that the mechanic who started the job would see it through to completion, since the job was passed back and forth between two rather than three crews.

The nature of the work being done by these groups was described as being very different from that of the operators. The work has a greater physical component, is more varied in terms of location, is much more self-paced and requires less of an on-going overall view of the entire system. Maintenance mechanics and control technicians do not encounter the difficulty faced by operators of getting up to speed on plant status after an absence of several days. When members of this group are absent there is no requirement that they be replaced by someone else who must work overtime to replace them. Since an extra maintenance crew is run on a days only 8 hour schedule, those workers who are really dissatisfied with shift work or 12 hour shift lengths can continue at their jobs on this crew.

Many people expressed dissatisfaction with the supernumary period because it requires them to go back to 8 hour shifts for 5 days in a row. Since very little

of this time is used for training for these workers, many resented having to work them when they were given what they felt to be "make work" jobs. A number of workers made the comment that administrative staff who work days work 35 hours whereas shift workers work 40. Eliminating the supernumary days would make their work week equivalent to a 35 hour week.

Several workers commented on the 24 hour maintenance policy of Ontario Hydro and noted that other industries keep night maintenance crews for emergency purposes only.

III.4 Discussion of Interviews

The majority of operators and maintenance personnel (including maintenance supervisors) preferred 12 hour shifts over 8 hour shift, and indicated that the majority of their colleagues felt similarly. The greatest preference for 12 hour shifts was shown by maintenance personnel who were overwhelmingly in favour of them. While the majority of first operators were in favour of 12 hour shifts, the preference was less marked. The few supervisors who had experience of both 8's and 12's were the least enthusiastic about 12's.

In the course of the interviews, it became evident that differences in the strength of preference for 12's versus 8's are likely to arise from the nature of the responsibilities, tasks and working environments of the various work groups. During normal operation a great deal of the first operator's time is taken up with monitoring the plant. System safety tests are done all together at the beginning of the shift, after which there is a long period of monitoring. Many research studies show the difficulty of remaining alert and interested in monitoring tasks which endure for long periods of time. In contrast, as noted above, maintenance personnel do work that has a much larger physical component to it, is much more varied in terms of physical location, is much more self paced and requires less of an on-going overall view of the entire system. All these factors contribute to making maintenance work easier to sustain over a 12 hour period. In addition to the differences between these groups in the nature of the work, there is a difference in responsibility. As noted in the report "Analysis of Human Errors at Pickering NGD-A, 1978 to 1981" :"panel operators, by definition of their work responsibilities, are the group most able to affect the safety system and hence, commit human errors that fall into the category of an SER-type event." It is possible that one reason for operators being less keen on 12 hour shifts than maintenance crews is that this exposure to longer periods of high responsibility for safe operation adds to subjective workload.

Another major difference between these work groups is the difference in their freedom from the demands of overtime. Maintenance workers who are absent for sickness do not routinely face the prospect of forcing a colleague to be called in on overtime, nor have maintenance workers been in the position of having to work each other's vacations. This dependence on each other for coverage is an added pressure on first operators and could result in their working when they are tired and/or unwell.

It is worthy of comment that control room operators and maintenance personnel are treated similarly by management and by their own union in terms of shift scheduling. Thus, for example, first operators work 12 hour shifts, though given the

nature of the job, 12 hour shifts are less appropriate for them than for maintenance personnel. Both operators and maintenance personnel have the same scheduling of supernumary days. Supernumary days are a set of 5 8 hour day shifts (Monday to Friday) which occur once in each 35 day shift cycle. Despite the fact that maintenance personnel require much less training and retraining time than first operators, they have as many supernumary days scheduled. Overtime and schedule restrictions are the same for both groups. In some cases, for efficient functioning of the team, this similarity of schedule is necessary. However, given the different circumstances of the two jobs it is not always appropriate. For example, many maintenance personnel resented having to go back on 8 hour shifts for 5 days during the supernumary period, when this time was not used for training.

Not only were control room staff less keen on 12 hour shifts than maintenance staff, they were also more likely than maintenance staff, to suggest reducing the work week to 35 hours, like that of administrative staff on day shift, who were not subject to constant time changes.

In terms of improving the work situation with regard to shiftwork, both control room supervisors and operators pointed to a need for more licensed first operators. There was a great deal of resentment expressed by some of the operators about the fact that, until recently, in order to take their own vacation, they had to cover someone else's. More licensed operators per shift would relieve this problem, as well as a coming problem, that of providing coverage when requirements for refresher training increase. A number of operators and supervisors pointed out that other nuclear plants have 6 licensed operators per shift. First operators face a lifetime of shiftwork if they wish to continue to work as first operators, unlike maintenance personnel or supervisors. Given this fact, the suggestion by one supervisor that first operators take all their training in a 3 month period, during which they can live a "normal" life, at regular intervals, seems one worthy of consideration.

Turnovers were noted as a problem by many shiftworkers, both because of their frequency and because of the short period of time off for recovery between nights and days. Some wanted to increase the numbers of nights worked in a row, pointing out that by the time you had completed 3 nights you were well on your way to being adapted to nights anyway, so why not add a fourth and reduce the number of turnovers. Others felt that 3 nights in a row was as much as they could take and a fourth would be too exhausting. Knowledge of circadian rhythms and effects of shiftwork suggests that the turnovers ought to be less difficult after 2 nights are worked as compared to after 3 nights, since less adaptation has taken place. Findings from the shiftwork literature also suggests that 4 nights in a row would be very fatiguing (e.g. study by Rosa et al, 1988, showing significant changes in self reported stress on the fourth through sixth days of shiftwork). Fatigue arises because of long hours worked in a short period of time, and also because of the sleep debt of about 1.5 hours which accumulates with each night worked. The best approach to reducing the problem of turnovers, from the point of view of the literature, would be to have fewer (i.e. 1 or 2) nights in a row rather than more.

Personnel in all groups felt a lack of appreciation by administrative staff who work days of the special difficulties of shift work. Both operators and main-

tenance personnel noted that Ontario Hydro has a 24 hour operation policy, unlike other industries. People felt that management should recognize that people are at a low point in the early morning hours, rather than assuming work should be scheduled at this time of day in the same way as during the rest of the 24 hour period. A number of people commented that the problem was not with 8 hour or 12 hour shifts per se, the problem was the low point in the early morning hours. Literature on circadian effects would suggest that the low point in performance would be lower after more hours of work (i.e. it would be expected to be worse on 12 hour shifts than on 8's). Nonetheless, this early morning low point should be recognized in work planning, no matter what the shift length.

Many of those interviewed about their preference for 12's versus 8's commented on how difficult they had found the 8 hour schedule. A number of unpleasant features of this schedule were noted, including working for long stretches of time with single days off which were totally taken up in adapting to the time of the next shift, and the frequent occurrence of 16 hour work days when overtime was worked as a double shift. The schedule was also of the type which rotated every week. This is now recognized by experts on shiftwork to be the worst possible schedule since it means the shiftworker is in a continual process of adaptation to a new schedule. (One never fully adapts to night shiftwork and the adaptation that does take place requires 6-10 days to be completed.) Current evidence suggests that the best 8 hour shift schedules are the short rotating shift schedules used in Europe. These schedules have only 1 or 2 night shifts at a time, followed by rest days. By these means the body is not given enough time to start adapting and stays adapted to the normal circadian rhythm rather than changing back and forth. European 12 hour schedules have this same feature. One such short rotating schedule is one 12 hour day, one 12 hour night, and 2 days off (giving an average of 42 hours per week). The 12 hour schedule now in place at Ontario Hydro does avoid both long sequences of shifts (3 is the maximum) and long periods of work (a double 12 hour shift being unthinkable). It is not surprising on these grounds that the 12 hour schedule is preferred by the majority. This raises the question of whether the preference would be so great if a better 8 hour schedule had been in place in the past.

It should be noted that for reasons of economy, the interviews with nuclear power plant personnel were only conducted at Bruce A and Bruce B NGD. Therefore the interview findings are specific to this group. However, as part of the Ontario Nuclear Safety Review which took place in 1987, the senior author of this report also interviewed operators and maintenance personnel at Pickering NGD on the subject of shiftwork. Responses in regard to shiftwork on the part of these two groups were similar.

III.5 Overtime Hours at BRUCE NGD

Information on current levels of overtime for operators at Bruce NGD was furnished by the Health Resources group there. During 1988 pay records had been computerized in a manner which made it relatively simple to obtain data on overtime worked. Data on number of operators working more than 60 hours per week, number of operators working more than 14 hours in one shift and number of operators working more than 3 night shifts in a row were collected. These statistics were selected since they were also collected for the fourth quarter of 1985 and reported in the 12 hour shift monitoring reports. In this report over-

time data were not broken down for each operator classification, but were reported for all operators together. Information was provided for each of first, second and assistant operator groups at Bruce A for the entire 1988 year, and for Bruce B for the first 6 months of 1988. The interviews with the first operators suggested that their overtime situation had improved considerably over the past year or so. Indeed information provided for first operators showed that in 1988 few worked much overtime. Currently it is the assistant and second operators who are working the bulk of the overtime, and, in some cases, at levels exceeding those in 1985.

At Bruce A the percent of operators who exceeded the 60 hour rule during the last quarter of 1985 was 30%; in 1988 the quarterly rate was much lower, 8%. There was, however, an increase in the rate of working more than 3 nights in succession. In 1985 this was 38%; in 1988 it was 53%. As noted earlier, the data provided for first operators at Bruce NGD showed that in 1988 they did not work a great deal of overtime. Thus most of the overtime was worked by assistant and second operators. The 53% figure means that slightly more than half of the assistant and second operators worked 4 or more consecutive night shifts in each quarter. Since overtime is voluntary, it is highly likely that some assistant operators do not work much overtime, while others are working a great deal.

At Bruce B the overtime situation in 1988 was worse than in 1985, and again the problem was with the assistant and second operator groups rather than with the firsts. In the last quarter of 1985 15% of all operators worked more than 60 hours in a fiscal week, while in 1988 the rate was more than double, 38%. The rate for all operators working more than 3 nights in a row also increased between 1985 and 1988 from 12% per quarter to 18%.

Despite the introduction of stricter guidelines for overtime after 1985, there was still a considerable amount of overtime worked at Bruce NGD in 1988. In particular it is of concern that there were so many instances in which the 60 hour maximum rule was broken, 72 instances at Bruce A in the whole of 1988 and 173 instances during the first 6 months of 1988 at Bruce B. The fact that this rule must be broken so frequently suggests staffing is inadequate. In 1988 the operator groups who worked the most overtime were the assistants and seconds rather than the firsts.

For maintenance workers at Bruce, the monitoring report showed that there were fairly high levels of overtime at Bruce B, with 27 instances among 87 employees of the 60 hour week being exceeded. At Bruce A the situation was better with only 9 such instances amonst 85 employees. It was evident from the interviews that maintenance personnel are currently working very little overtime. Some interviewees complained that there wasn't "enough". Since they are not required to cover each other's absences to the same degree as operators, it was not felt necessary to obtain further data on current overtime hours for this group.

IV SIGNIFICANT FACTORS NOT YET CONSIDERED ADEQUATELY

IV.1 Schedule Design

In general terms, the design of the current shift schedule is as follows. The shift cycle is 35 days or 5 weeks in length, after which the cycle repeats. The

schedule is set up so that the various shift sequences always fall on the same days of the week. For example, the 3 nights in a row occur once within the 35 day cycle, and always fall on a Friday, Saturday and Sunday. (The rationale here is that if a weekend is going to be disrupted, better to totally disrupt it.) There are 3 out of every 5 weekends off. All shifts last 12 hours with the exception of the supernumary days which occur toward the end of the 35 day cycle. There are 5 supernumary days in a row, each being an 8 hour day shift. In July and August, the supernumary days are days off. This allows two 9 day periods off in the summer (the 5 supernumary days with a week-end at each end).

Examination of the official Ontario Hydro 12 hour shift schedules reveals the following:

1) a sequence of 3 night shifts in a row occurs once within the 35 day cycle and is followed by 48 hours off before the next series of day shifts commence

2) a sequence of 2 night shifts in a row occurs twice in the 35 day cycle; on one occasion followed by 48 hours off, and on the second occasion by 72 hours off preceding the supernumary days

3) a sequence of 3 day shifts in a row occurs once in the cycle and is followed by 72 hrs. off

4) a sequence of 2 day shifts in a row occurs twice in the cycle and is followed by 96 hours off (4 days) on one occasion, and by 72 hours off (3 days) on the other occasion

There are two ways in which knowledge about the effects of shift work on sleep and performance might be applied to improve this schedule. First, because no more than 3 night shifts are worked in a row, little adaptation to the night schedule takes place. In the first two nights in particular, workers' circadian clocks can be expected to be set on normal time. The result of this is that workers will have difficulty sleeping during the day and will acquire a sleep debt for each night worked of at least one and a half hours. This is the sleep deficit known to be acquired for workers on an 8 hour schedule who work nights. It is probably longer for 12 hour shift workers who will have less of the day available to take naps. By the third day of night shifts, adaptation of the circadian rhythm to the new schedule will begin to occur. This means physiological functions of temperature, heart rate, blood pressure, etc. will have begun shifting so that the body is geared for action during the night rather than during the day. Along with the changes in physiological parameters go changes in performance and mental alertness. When three night shifts in a row are worked, adaptation to the new circadian rhythm gets started. The consequence is that the worker will have a harder time switching back to the day shift than he would if only two nights were worked in succession. A less fatiguing schedule would be one in which the number of successive night shifts was limited to two rather than three.

The second difficulty with the current schedule compounds the problem discussed above. Research on shift work shows that a sleep debt is incurred when one works nights. This suggests that the longest periods of time off should follow the night shifts, particularly the sequence of three night shifts after which a sleep

debt has to be paid off and circadian adjustment has to occur. In the Ontario Hydro schedule, the longest periods of time off follow the easiest shift sequence, two day shifts in succession, while the shortest period of time off follows the most difficult shift sequence, three nights. Reversing this would also contribute to a less fatiguing schedule.

IV.2 Age and Shiftwork

The Ontario Hydro report entitled 'Assessment of the Impact of 12-Hour Shifts on NGD Shift Performance' did not discuss the effect of age on tolerance of 12 hour shifts or shiftwork. The review of the latest available literature in the earlier section of this report concludes that though there is plenty of anecdotal evidence that older workers find 12 hour shifts long and find shiftwork more difficult to tolerate, there have been no field studies which have properly examined this issue.

The Ontario Hydro monitoring reports did attempt to look at this issue; however as was discussed earlier, the data were inadequate to identify differences in performance due to age. The interviews with Ontario Hydro shiftworkers brought out more anecdotal evidence of the connection between age and difficulty with shiftwork. Amongst the operators interviewed, it was the oldest who preferred the shorter 8 hour shifts. Indeed many operators characterized those who disliked 12 hour shifts as being older. In reference to the question on the effects of shiftwork on health, two supervisors commented on the greater difficulty older people have in rebounding. Amongst the maintenance personnel, comments were made that G crew (daytime 8 hour shifts) was mainly for older workers and those with health problems, and 'shiftwork was for the young'.

The issue of age is of concern for two reasons. First, nuclear workers are highly trained people and represent a valuable resource to management. There is a well-known tendency for people to leave shift work when they get older. Anything that accelerates this tendency should be avoided. Second, the nuclear field is a young field. The 1985 data on operator age profile shows that there are few older operators. The last Ontario Hydro quarterly monitoring report shows that out of a total of 874 NGD operators only 48 or 5.5% were over 45. Amongst mechanical maintainers, 8.8% were over 45; for control technicians, 10.3% were over 45. This is in striking contrast to the percent of workers over 45 in the Canadian labour force. According to Statistics Canada, in November 1988, 26% of the Canadian work force was over 45 years of age, almost 5 times the percent found among nuclear operators and 2 to 3 times the percent amongst the maintainers and control technicians. The bulk of nuclear workers are in the 25 to 34 year old range. As this group of operators ages, the proportion of older workers will grow. As noted above, anecdotal evidence suggests that older shiftworkers have more difficulty adjusting to shiftwork. Research on this issue would be valuable. Any problems in adjusting to shift work for older operators should be addressed in order that fatigue, which results in errors, can be avoided. As far as maintenance mechanics and control technicians this problem has been addressed already to a great extent, in that 8 hour day shift jobs are available. Unfortunately, for an operator to continue as an operator there is currently no alternative to the 12 hour shift schedule in place.

This interaction between age, shiftwork, fatigue and performance might be studied using a similar approach to that taken by Lewis et al (1986) at the Fast Flux Test Facility. Here objective measures of performance were obtained from a battery of tests which examined skills required in carrying out the nuclear operator's task. Also standardized scales were used to assess subjective fatigue. It is important to measure subjective fatigue because it is frequently a precursor to performance changes. Lewis and his colleagues note a number of problems in their study, such as a lack of practice on the test battery, and random testing over the 24 hour period, which should be avoided in any future study.

With such a field study, the correlation between age, fatigue, hours on shift and shift in cycle (first night, second night etc.) could be determined. By this means it could be established whether or not subjective fatigue and performance deficits due to fatigue increase with age. If this turns out to be the case, a number of options might be considered as operators age to encourage and allow them to remain working as operators. For example, with seniority (highly correlated with age), operators could be offered the option of working fewer hours in lieu of pay increases. Older operators could be exempt from overtime. Anything that reduces the number of hours worked and, in particular, reduces hours worked at night, would help offset the fatigue that builds up with shift work.

IV.3 Exercise and Shiftwork

In the interviews, a number of operators indicated that use of an exercise room was helpful in maintaining their alertness. Whether or not a half hour period does increase alertness or improve performance is unknown. This might be examined as part of the study on age and fatigue described above. If exercise is indeed helpful in maintaining alertness, then it should be encouraged and facilities provided where they do not currently exist.

IV.4 24 Hour Operation Policy

In interviews with maintenance personnel and control technicians, several people expressed the view that Ontario Hydro's policy of 24 hour operation as regards preventative maintenance was unusual. Apparently other industries, including the American and Korean nuclear plants, as well as steel making and mining operations in Canada, view the night maintenance crew as an emergency crew only. It is accepted though unofficial policy that night crews are not expected to stay awake and busy unless an emergency requires their presence. The authors confirmed that this was indeed the case at some American nuclear plants and at Dofasco in Canada. To some degree Hydro management has attempted to allocate more preventative maintenance during day shifts by having a "G" crew who work 8 hour days. Personnel who were interviewed recognized the fact that maintenance crews on night shift are less productive than on day shift simply because of fatigue. Literature on circadian rhythm effects on performance strongly suggests that if the same jobs are carried out at night as during the day there will be more errors. Studies in various industries show peaks in increased error of 75% to 200% at the circadian low periods of 3 - 6 am. For these reasons the allocation of as much preventative maintenance as possible to daytime periods is to be encouraged.

IV.5 Sleep Management Policy

Whatever the formal policy on sleeping during work breaks is, the informal policy varies greatly from supervisor to supervisor and from station to station. While conducting interviews with operators at Pickering for the Ontario Nuclear Safety Review, one of the authors of this report was told that sleeping on meal breaks at that station was not allowed while at Bruce NGD this appears to be tolerated according to the operating personnel who were interviewed. Almost every operator interviewed said that he experienced drowsiness from time to time while at work and particularly on the night shift. Amongst the maintenance staff, the average estimate of the number of workers who had a nap during the meal break was one third.

Both the American and Canadian military have shown a great deal of interest in the last 10 years in the area of "sleep management". Numerous studies have been carried out on the effects of naps on performance at both the Defence and Civil Institute in Environmental Medicine (DCIEM) in Downsview, Ontario and at the U.S. Naval Health Research Centre in San Diego. The results of these studies can be summarized as follows (Naitoh and Angus, 1987). Research shows that "a nap is invariably effective in maintaining performance and moods when a nap is taken prophylactically before degradation of performance and mood due to sleep loss and fatigue. These studies also confirmed that a nap will help restore degraded human functioning. " Studies also show that performance is reduced for a brief period of time immediately after awakening from a nap. This sleep inertia is of most importance where sleep loss has been severe and the nap, insufficient. Some of the DCIEM studies examined naps in a situation where subjects participated in a simulation of a brigade-level command post in which they assumed the role of duty operations officers who monitor a communications network, update tactical maps, read messages and answer questions. These studies found "greater decrements in performance following sleep loss combined with intensive mental work than previous studies with less emphasis on cognitive demands". To date, these military studies appear to have examined more extreme situations of sleep loss than would hopefully occur amongst nuclear operators.

In outages and during transients, operators can face situations where mental workload is high for many hours. During normal operating conditions, there are prolonged periods of monitoring, when mental workload is low. Fatigue and sleep loss have a greater impact on performance at these extremes than when workload is moderate. Since operators perform tasks that have been shown to be affected by fatigue and sleep loss, since they work schedules that have been shown to produce fatigue (due to long hours) and sleep loss (due to night shift work), since they themselves admit they suffer from sleepiness, particularly in the early morning hours, and since naps have been shown to maintain performance, it would seem reasonable the effect of a short nap on performance in conditions simulating those of operators should be investigated. This possibility is discussed further in section V. Policy on sleeping during breaks could be formulated once more evidence was available on its effect. Such policy could then be applied consistently, rather than according to the views of individual supervisors.

IV.6 Accident Risk While Driving Home After 12 Hour Shifts

Shiftworkers face the prospect of driving home from work in a very fatigued condition, particularly when they have been up all night with little sleep before

the shift started. A number of the shiftworkers interviewed noted that they had great difficulty staying awake while driving home. Moore-Ede (1989) notes that data on driving home accidents shows shiftworkers have double the accident rate of administrative staff who work days. These data are predominantly from companies on 8 hour shifts. It is likely that longer shifts will exacerbate any such tendency. The provision of buses for transporting personnel to and from the site at Bruce NGD is an excellent way of dealing with this problem. It would certainly be of interest to maintain statistics on such accidents. If shiftworkers are aware of the risk they run, they may be more inclined to take advantage of the transportation offered.

IV.7 Management Appreciation of the Stress Due to Shiftwork

Comments made by many of those interviewed, and particularly the operator group, indicated a perception that management does not appreciate the additional stress placed on a worker because of shift work. This is a difficult problem because if management does acknowledge the greater stress of shift work it will be expected to provide compensation for same. However, while compensation may improve employee relations it does not address the issue of concern here, which is how to reduce the fatigue and stress which inevitably arise for shift-workers. It is not sufficient for management to merely recognize the problem, though this is an important first step. Nor is it sufficient for management to expect employees to take on total responsibility for this problem. The Safety Engineering Unit of Ontario Hydro produced a document entitled "Working With 12-Hour Shifts: Suggestions for Employees". This is an excellent document and management should be commended for supporting its production. However, management also has a role to play in reducing the fatigue and stress generated by shiftwork. There are a number of ways in which this greater stress is not acknowledged. These are as follows.

Overtime can produce fatigue in daytime workers. However it is even more fatiguing to shiftworkers. Where possible, overtime should be avoided, especially for first operators whose work is of a nature that makes long hours stressful. Manpower planning to avoid overtime should be encouraged. It is not acceptable to allow a situation where workers must work each others' vacations in order to take their own. The recuperating effect of a vacation is severely compromised in this situation. Obviously overtime will always be necessary, but manpower planning which emphasizes as little overtime as possible will avoid situations like that described above.

The circadian low points in performance in the mid-afternoon, and especially in the early morning hours are well known. Work scheduling should take them into account where possible.

Shift workers spend a significant portion of their "time off" recovering from the effects of time changes. For example, many workers who come off a sequence of nights, find that they must force themselves to get up at noon or 1:00 pm after a few hours sleep and then feel lousy for the rest of the day in order to ensure they will be able to sleep that night and become readjusted to days. This "day off" does not have the same quality as the day off taken by a day only worker. Despite this, shift workers work 4 hours longer per week than administrative staff who work days. If anything, this situation should be reversed. While it is true that shiftworkers have a paid half-hour lunch (amounting to 2.5 hours a

week), they are expected to be available if necessary, during lunch. Some operators said that during busy periods they do not take any lunch breaks.

Many workers interviewed resented the very small shift premium paid on the night shift. Working at night is as much an inconvenience and a disruption to family life as working on statutory holidays and weekends. Yet working during these latter periods is much better compensated that working at night.

Shift workers are known to have higher rates of illness due to the stress of shiftwork. Despite this, they are allotted the same number of sick days as administrative staff who work days.

In addition to these issues discussed above, there were a number of smaller irritations commented on by the shiftworkers interviewed that suggested to them that management neither appreciated nor understood the special difficulties of shift workers. (See general comments in each of the interview reports in Appendix B.) Currently, managers receive training on dealing with employee alcohol and drug use. It might improve communications and work planning if they also received some training on how shift work affects circadian rhythm and, as a result, performance, sleep quality, health and family life.

A final point on this issue is that there is currently no consideration given to shiftwork adaptability in the selection process for nuclear workers. There are pen and pencil tests available which help identify people who will have difficulty adapting to shift work. (Such people tend to be 'morning' people with very inflexible sleeping habits). Such people could at least be warned in advance that they should think carefully before getting into shift work. A number of the shift-workers that were interviewed commented on colleagues who had great difficulties getting adequate sleep, and should never, in their opinion, have taken jobs involving shiftwork.

V RECOMMENDATIONS

As a result of reviewing the literature, reviewing Ontario Hydro reports related to the introduction of 12 hour shifts, and carrying out interviews with 34 station personnel working 12 hour shifts, the following recommendations for further action and further research by AECB are made.

V.1 Further Actions

1. AECB should consider increasing the requirements for the minimum number of licensed first operators per shift from the current requirement of four. The required minimum should allow operators to complete required training and requalification and take their vacations without necessitating that they work overtime to do so.

2. AECB should consider a requirement that workers have at least 72 hours off between the end of a night shift and the beginning of the next day shift, in the regular schedule, and at least 48 hours off when overtime is worked.

3. AECB should set down requirements for the reporting of overtime exceeding certain levels.

The rationale for each of these recommended actions is given below.

1. Minimum Licensed First Operator Requirements

Interviews with 8 first operators, 1 second operator and 6 supervisory staff made clear the fact that 4 licensed operators per shift is an insufficient minimum. With the current shift schedule there are approximately 40 supernumary days per year. According to the operator interviews it is during the supernumary period that operators try to take their vacation time. As supernumary days become "locked-in" with the requirements for requalification, there is concern that more and more vacation time will have to be taken outside of the supernumary period. The problem with this is that vacation taken outside of this period necessitates another operator working overtime to cover it. In the interviews several operators said that for some years they had had to work someone else's vacation in overtime in order to take their own. At Bruce NGD this has apparently improved over the last year for first operators (though not for assistant operators) but there is concern that it will get worse again when requirements for increased simulator training and requalification are brought in.

Since it is insufficient staff that leads to overtime, the problem of too much overtime should be addressed directly by requiring an appropriate minimum number of licensed first operators, rather than by placing limitations on overtime. Obviously any requirement in this area would need to recognize the difference between manning and staffing. Requiring each shift to be manned by 6 first operators would be inappropriate, and would produce the same problem of overtime as exists currently.

From the Bruce NGD Health Resources data on overtime it is clear that there are also insufficient assistant and second operators. AECB should consider whether a minimum staffing complement is also required for these groups.

2. Recovery Period After Night Shifts

It is evident from the literature on shift work that working 8 hour night shifts results in a sleep debt (of about 1.5 hours per night). Because 12 hours, rather than 16, are available for sleeping after a 12 hour night shift, this sleep debt is liable to be the same or greater after a 12 hour shift, but certainly not less. Because of this sleep debt, experts on scheduling recommend that days off follow a sequence of nights. In the case of Ontario Hydro schedules only 48 hours recovery time is given after all of the 3 night sequences and after half of the 2 night sequences. It is the opinion of the authors, based both on a general knowledge of the shift work literature as well as interviews with Ontario Hydro shiftworkers, that 48 hours is barely adequate. As discussed in section IV.1 it would be preferable to have the longer recovery period after the night shift sequences than after the day shift sequences as is the case now. In the opinion of the authors, the recovery period after night shifts in the regular schedule should be 72 hours. This would allow an additional night shift to be added, if necessary, for overtime work, without reducing the recovery period to less than 48 hours.

The limitations suggested in this report would not prevent a situation where 4 nights in a row were worked followed by 48 hours off. Since 4 nights would allow a shiftworker's circadian clock to get quite adapted to nights, 48 hours off

would be insufficient recovery time. Limiting the number of nights worked in a row to 3 to prevent such an occurrence would be wise but might be overly restrictive. According to most of the operators, most of their overtime was planned over time. The authors suggest that no restriction be made to prevent 4 nights followed by 48 hours off, but that when overtime is planned, as opposed to unexpected, that this situation be avoided.

It might be noted that merely reversing days and nights in the current schedule would have the desired effect of increasing recovery time after night shifts to 72 hours or more. It would also result in starting the shift schedule on a night shift. Control room personnel indicated that this would allow them to get up to speed on plant status more easily. Finally, the 3 free weekends out of 5 feature of the current schedule, which many shiftworkers felt strongly about, would be retained.

3. Reporting Requirements

If a policy is to be effective it should be adhered to. At the moment there appears to be no requirement for plant managers to report overtime being worked. The AECB might consider introducing reporting requirements for overtime exceeding that outlined in the AECB policy.

V.2 Further Research

In addition to the actions outlined above the following research and studies are recommended for consideration.

1. AECB should support research into the impact of a half hour nap and a half hour period of exercise on performance of tasks equivalent to those of the first operator.

2. AECB should support research into the effects of age on subjective fatigue and performance of shiftworkers. Such a study could also examine the correlation between subjective fatigue and the following variables: age, time on shift, day in shift cycle, and satisfactory (to the operator) sleep patterns

3. AECB should consider requesting Ontario Hydro to extend the 12 hour shift monitoring program that finished in April 1986 to look at the effects of overtime on error rates.

The rationale for selecting these topics for further research is given below.

1. Effects of Naps and Exercise on Performance

Many operators noted the difficulty of night shifts. It was evident from the interviews that the majority of operators experience sleepiness, especially in the early morning hours. The operator's task at that time of day is mainly monitoring. Under the best conditions, human operators are limited in their ability to perform monitoring takes over long time periods. Performance on this task is known to be degraded both by fatigue due to number of hours worked and/or reduced sleep as well as by fatigue which arises from being at a low point in the circadian cycle. In the early morning hours operators are subject to fatigue due to hours already worked (7 hours at 3:00 am), fatigue due to being at the circadian

low point of the day, and probably very frequently, fatigue due to lack of adequate rest during the day before the shift started. Many people are greatly refreshed by a short nap. Research suggests that recovery time after awakening is on the order of a few minutes. Similarly many people claim to be refreshed by a period of exercise, although the authors are not aware of studies, such as those on naps, supporting the effectiveness of exercise in reducing performance deficits.

In any case, the effects of both naps and exercise on performance of first operators should be examined. It is not possible, even with the best intentions, to force oneself to sleep, at a high point in the circadian rhythm, in order to prepare for a night shift. If short naps or exercise periods will reduce sleepiness and improve performance on nightshifts, they should be encouraged.

2. Effects of Age on Subjective Fatigue and Performance

As noted in section IV.2 there is anecdotal evidence that shiftwork is more difficult for older operators, but there is not as yet any objective evidence of increased fatigue or of increased deficits in performance. The type of study outlined in section IV.2, using subjective and objective measures, would provide some basis for adopting a policy which would aid older operators in combating fatigue, if indeed they were subject to greater fatigue. Such a policy might include the option of reduced hours of work. A study such as that described would help fill an important gap in the scientific literature on shiftwork. Given the extensive training of nuclear workers, and the coming increase of older workers, it would be worthwhile having some hard data on the effects of age on shiftwork, which would be helpful in determining ways of alleviating any negative effects.

3. Monitoring Program to Assess Overtime Effects on Performance

Each time a significant event occurs which is deemed to be due to human error, data on hours of work for the personnel involved should be collected. These data should include the following: time of day of the error, hours since the start of the shift, total number of hours worked in the previous week, in the previous month, number of days since the start of the last 35 day cycle, whether that cycle was preceded by 9 days off or by a week of supernumaries. Baseline data needed to normalize data on error rates includes percent of person hours which are overtime hours over the period during which error data were collected and percent of time the units were shutdown. The Ontario Hydro report on errors at Pickering, showing error rates during shutdown were 4 times as high as during normal operation, suggests data on plant state is needed to normalize error rate data.

VI EVALUATION OF 12 HOUR SHIFT OVERTIME POLICY

There are a number of considerations in evaluating an overtime policy. These are as follows:

1. Does the policy result in a recovery time between the end of a sequence of night shifts and the beginning of a sequence of day shifts of less than 48 hours?

2. Does the policy allow more than 5 days in a row or 4 nights in a row?

3. Does the policy allow a shift to last longer than 16 hours in a row?

4. Does the policy set a limit on total time worked in a one week period, as well as in at least one larger period, for example within the 35 day period?

5. Does the policy include reporting requirements to ensure it is adhered to?

On the first point, the need for adequate recovery time has been discussed in section V.1. In the opinion of the authors, the absolute minimum recovery time between the end of a sequence of night shifts and the beginning of a sequence of days is 48 hours. Overtime should not be allowed to reduce this further. Moving from a day shift sequence to a night shift sequence is not as serious an issue since there is not a sleep debt to pay off. Also the mechanics of the schedule are such that, unless one works 24 hours straight, there will be at least 40 hours off between the end of a day shift and the start of the next night shift.

On the second point, data from various industries suggests that work performance starts to deteriorate and absenteeism to increase for work weeks longer than about 44 hours. Because of the sleep debt accumulated when working nights, the limitation on the number of night shifts worked in a row should be less than that on the length of a sequence of days. Five days is equivalent to a work week of 60 hours. This is the maximum that should be allowed. Nights, which are more fatiguing, should be limited to 4 in a row.

On the third point, there is clear evidence in the literature on hours of work that obvious deterioration starts to set in after 14 - 16 hours work. An overtime policy that allowed work to exceed 16 continuous hours would not be a safe one.

On the fourth point, in the opinion of the authors, the 35 day cycle should be used as a basis for setting a limit on overtime, over and above the 60 hour per week maximum. The limit should depend on whether or not the period of supernumary days at the end of the previous 35 day cycle was worked or taken as days off. Many workers interviewed noted the importance of days off during the supernumary period for adequate recovery. A suggested limit is 4 extra overtime shifts if the preceding supernumary period was taken as days off and 3 extra overtime shifts if it was not.

Below are shown two schedules. The one on the left is the regular schedule. The one on the right is a schedule which includes 4 extra shifts. This schedule neither exceeds the 60 hour guideline, nor exceeds a guideline which the authors strongly feel should be in place, that is the 48 hours minimum off between the last night and the first day of a sequence.

REGULAR SCHEDULE	OVERTIME SCHEDULE	
TFSSMTW	TFSSMTW	
RRNNNRD	RRNNNRD	
DRRRRNN	DRRNNNN	
RDDDRRR	RDDDDDR	
NNRRSSS	NNRRSSS	(D: day, N:night, R:day off,
SSRRDDR	SSRRDDD	S:supernumary day (8 hours)

The shift ends (rather than starts) on the day shown i.e. the first shift at the beginning of the fourth week on the regular schedule is a night shift which ends at 8:00 am that morning)

If a worker started the overtime schedule having had the previous supernumary period off, this schedule would be fatiguing but, in the opinion of the authors, not unacceptably so. However, without this previous period off one would expect the worker to be too fatigued by such a schedule. It is recommended that AECB consider a limit of 3 extra shifts in a 35 day cycle where the prior supernumary period was worked, and 4 extra shifts when this period was not worked. Such a limit would restrict total overtime hours worked in a year to approximately 456. This is calculated as follows. There are approximately 10 35 day cycles in a year. Of these, 2 cycles have supernumary days off. During these 2 cycles, a total of 8 (2 x 4) extra shifts could be worked, for a total of 96 (8 x 12) hours overtime. In the other 8 cycles 3 extra shifts per cycle could be worked, for a total of 24 (8 x 3) extra shifts or 288 hours overtime. Thus the total overtime for the year would be 456 hours, somewhat less than the current limit of 600 hours. The advantage of such a limit is that it takes account of the condition in which the shiftworker starts the cycle, in determining how much overtime should be worked.

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APPENDIX A1: QUESTIONNAIRE ON SHIFTWORK: CONTROL ROOM PERSONNEL

Operators will be assured that their answers will be confidential, in that the report on the interviews will not identify individual operators or quote specific incidences which could be easily linked to a particular operator. Operators will be asked to consider the last year only when answering questions on number of shifts worked in a sequence, number of hours worked continuously etc.

General Attitude towards 12 Hour Shifts

1. Which do you prefer, the 12 hour shift schedule, or the old 8 hour shift schedule? Why?

2. I understand there are some operators who prefer 12 hour shifts and some who dislike them. What characteristics, in your opinion, distinguish these two groups?

3. Has your attitude towards 12 hour shifts changed since they were introduced? In what way? Why?

4. What percent of the first and second operators would you estimate would prefer to go back to 8 hour shifts?

Organization of Work

5. Do you organize your work differently on the 12 hour schedule compared to the 8 hour schedule? If so, how?

6. Do the day and night shifts differ in the nature of the tasks that are performed? What periods of the day(night) mainly consist of monitoring?

Official Schedule vs. Practice

7. How often does the total turnover time for a shift exceed half an hour?

8. How often do you work longer than 12 hours on a shift?

9. What is the longest period you have ever worked continuously? Under what circumstances did this occur?

10. What is the most frequent reason for working longer hours?

11. What is the most number of dayshifts you have worked in a row? Night shifts?

12. Have you ever had less than 48 hours off between the end of a night shift and the start of a day shift? If yes, under what circumstances? How frequently has this occurred?

13. Do you feel there are ways in which the shift schedule could be improved? If so, how?

14. How would you feel about reducing the number of night shifts worked in a row to 2 to prevent yourself from starting to adapt to nights?

15. How would you feel about having more time off after the 3 night sequence but less time off after the 2 day sequence to balance this? Why?

OVERTIME

16. How frequently are you called in unexpectedly (i.e. for overtime that is not planned)?

17. How frequently do you trade shifts with someone else?

18. Is there ever pressure to work overtime when you would prefer not to?

BREAKS

19. Could you describe the type and length of breaks you usually take during the course of a 12 hour shift? Do the day and night shifts differ in this regard?

20. Do you feel the total length of breaks you are officially allowed is adequate? If not, what break schedule would be adequate?

FATIGUE

21. Please mark on this schedule which shift you find most difficult. If there are several of equal difficulty please mark them all. Why do you find this(these) shift(s) difficult?

22. During what time periods is it most difficult to remain alert?

23. What techniques do you use to remain alert?

24. Do you ever find yourself or do you notice others nodding off briefly? If yes, how often?

25. Do you or others ever need to sleep during your meal break? How often?

26. There are a number of jobs where workers sleep under designated conditions while on duty. Is there any way work could be organized so that it would be possible for operators to take a nap during the night shift?

ORGANIZATION OF SLEEP

27. How do you arrange your sleep at home when you work nights? when you shift from nights to days? when you shift from days to nights?

EFFECTS ON HEALTH

28. Do you feel that working longer shifts has had any adverse effects on your health?

Second Jobs

29. Do you notice if there are more people with second jobs since the introduction of the 12 hour shifts?

Effects of Long Periods of Time Off

30. After an absence of several days, or after a major change in plant status, do you experience any difficulty in getting up to speed on the plant status? What could improve this situation?

APPENDIX A2: QUESTIONNAIRE ON SHIFT WORK: MECHANICS, CONTROL TECHNICIANS AND SUPERVISORY PERSONNEL

Personnel will be assured that their answers will be confidential, in that the report on the interviews will not identify individual persons or quote specific incidences which could be easily linked to a particular person. Personnel will be asked to consider the last year only when answering questions on number of shifts worked in a sequence, number of hours worked continuously etc.

General Attitude towards 12 Hour Shifts

1. Which do you prefer, the 12 hour shift schedule, or the old 8 hour shift schedule? Why?

2. Has your attitude towards 12 hour shifts changed since they were introduced? In what way? Why?

3. What percent of the maintenance mechanics (control technicians, supervisors) would you estimate would prefer to go back to 8 hour shifts?

Organization of Work

SUPERVISORS ONLY

4. Do you organize the work of your staff differently on the 12 hour schedule compared to the 8 hour schedule? If so, how?

5. Do the day and night shifts differ in the nature of the tasks that are performed? For example, do more difficult jobs tend to be done during the day? Would you say jobs done on the night shift take longer to complete or result in more errors?

6. Are there periods of the day (night) shift in which there is very little to do?

Official Schedule vs. Practice

8. How often do you work longer than 12 hours on a shift?

9. What is the longest period you have ever worked continuously? Under what circumstances did this occur?

10. What is the most frequent reason for working overtime?

11a. What is the most number of dayshifts you have worked in a row? Night shifts?

11.b How frequently do you work overtime?

12. Have you ever had less than 48 hours off between the end of a night shift and the start of a day shift? If yes, under what circumstances? How frequently has this occurred?

13. Do you feel there are ways in which the shift schedule could be improved? If so, how?

14. How would you feel about reducing the number of night shifts worked in a row to 2 to prevent yourself from starting to adapt to nights?

15. How would you feel about having more time off after the 3 night sequence but less time off after the 2 day sequence to balance this? Why?

Overtime

16. How frequently are you called in unexpectedly (i.e. for overtime that is not planned)?

17. How frequently do you trade shifts with someone else?

18. Is there ever pressure to work overtime when you would prefer not to?

Breaks

19. Could you describe the type and length of breaks you usually take during the course of a 12 hour shift? Do the day and night shifts differ in this regard?

Fatigue

20. Please mark on this schedule which shift you find most difficult. If there are several of equal difficulty please mark them all. Why do you find this(these) shift(s) difficult?

21. During what time periods is it most difficult to remain alert?

22. Do you ever find yourself or do you notice others nodding off briefly? If yes, how often?

23. Do you or others ever need to sleep during your meal break? How often?

Organization of Sleep

24. How do you arrange your sleep at home when you work nights? when you shift from nights to days? when you shift from days to nights?

Effects on Health

25. Do you feel that working longer shifts has had any adverse effects on your health?

Second Jobs

26. What % of other mechanics (control technicians) have second jobs?.

Effects of Long Periods of Time Off

27. After an absence of several days, or after a major change in plant status, do you experience any difficulty in getting up to speed on the plant status? What could improve this situation?

APPENDIX B: INTERVIEW RESULTS

1. FIRST OPERATOR RESPONSES

PREFERENCE WITH RESPECT TO SCHEDULES

1. Which do you prefer, the 12 hour shift schedule, or the old 8 hour shift schedule? Why?

3. Has your attitude towards 12 hour shifts changed since they were introduced? In what way?

4. What percent of first and second operators would you estimate would prefer to go back to 8 hour shifts?

Of 9 operators, only 2 said they preferred the 8 hour schedule. Interestingly, these 2 were the oldest of the group. Several operators qualified their choice of the 12 hour schedule by first stating that shift work in general was unattractive, but given the choice the 12's are the best of a bad situation. The extra weekend off (3 out of 5 vs. 2 out of 5 on 8's) as well as an increase in days off seemed to be the main reason for this preference. Three operators said they had been apprehensive about the 12 hour shift system when it was introduced, but felt more positive about it since they had worked it over the past two years.

Estimates made by the interviewees of the number of first operators who would like to go back to 8's were consistently low including those made by the 2 operators who would prefer to go back to them. Where actual percentages were offered, they were: 20 -30%, 25%, 25%, 30%, and 40%.

INDIVIDUAL DIFFERENCES AND SHIFT WORK

2. I understand there are some operators who prefer 12 hour shifts and some who dislike them. What characteristics, in your opinion, distinguish between these two groups?

Of 8 operators who responded to this, 5 said that operators who dislike 12 hour shifts tend to be older: 1 said that age didn't matter. Several pointed out that 12 hour shifts were less of a problem where the operator's children were younger than school age because they were home all day. With younger school age children, however, the operator would be completely out of touch with them during the sequence of day shifts, which make the 12's less attractive to this group. There appeared to be two distinct groups: those who liked concentrating their work hours so that their time off was longer and those who disliked spending the entire day working and having to do odd jobs, like mowing the lawn, on their full days off rather than doing this for a change of pace at the end of an 8 hour day. One operator who responded to this question said that operators who disliked 12's suffered from sleep problems. Several operators commented on the need to be extremely disciplined in the way they obtained sleep, particularly during the short turnover between midnights and days.

ORGANIZATION OF WORK

5. Do you organize your work differently on the 12 hour schedule compared to the 8 hour schedule? If so, how?

Do the day and night shifts differ in the nature of the tasks that are performed?

Organization of work on the 12 hour as compared to the 8 hour shifts appeared to differ in two ways. First the system safety tests were split between two shifts instead of three and thus occupied more time at the beginning of the shift than they used to. Second, there is an extra daytime maintenance crew (G crew) so that there is more interaction with maintenance during the day shift.

OFFICIAL SCHEDULE VS. PRACTICE

7. How often does the total turnover time for a shift exceed half an hour?

In response to this question operators said turnover time was normally 15 to 20 minutes. They thought it was more than this either "rarely" or less than one third of the time. The buses which take operators back to Kincardine and Port Elgin leave at 10 minutes past the hour. Operators who use these must be provided with a taxi if they do not have a car and the turnover lasts too long, which happens rarely. However, one operator said many operators don't use the buses because they are too pressed to get to them in time.

8. How often do you work longer than 12 hours on a shift?

Working more than 12 hours on a shift appears to be very unusual. In fact several operators noted that 16 hour shifts occurred more frequently on the 8 hour schedule where operators would work a double shift. However, because double shifts are unimaginable with 12's, another operator is always called in when illness or other unforeseen circumstances has prevented the originally scheduled operator from showing up.

9. What is the longest period you have worked continuously?

The first interviewees indicated so clearly that 16 hours was an exception that this question was not asked of all operators. Also information on this question was compiled for all operators at Bruce over the past year and is given in the main body of this report.

10. What is the most frequent reason for working longer hours (overtime)?

When it became clear after the first few interviews that the frequency of working over 16 hours was rare, this question was rephrased to refer to overtime in general. It was clear from the interviews that the most frequent reason for working overtime was staff shortages. Operators discussed the problem of not really having any vacation, because in order to get vacation, operators had to cover for each other. Because there was only the minimum complement of 4 licensed first operators per shift for some time, all absences including vacation had to be covered by these operators working overtime. Operators were naturally reluctant

to take sick leave even when they really needed it, because they knew this would result in another operator having to work overtime. This situation has eased somewhat in the last year with the addition of more licenses.

11. What is the most number of dayshifts you have worked in a row? Nightshifts?

From the first few interviewees it appeared that 4 nights was not uncommon because overtime on nightshifts was carried out by having an operator extend a period of nights rather than have an operator work a night in the middle of a period of days off. Five shifts in a row appeared to be an exception. It also appeared that trading shifts ("mutuals") amongst first operators was rare. (Thus recorded work hours would fairly accurately reflect actual work hours.) Because more information on this question could be provided by the hours of work summary, after the first few interviews, operators were not asked this. Several operators pointed out that the problem of working many shifts in a row was much worse on 8's.

12. Have you ever had less than 48 hours off between the end of a night shift and the start of a day shift? If yes, under what circumstances?

Several operators pointed out that in order to cover a night shift in someone's absence, the usual practice was to ask an operator who had already worked 3 nights, and was therefore partially adapted to nights already, to work an extra night shift. This results in 24 hours off between the last night worked and the beginning of the next shift. It appeared that the 60 hour rule is the primary rule adhered to in deciding how to handle overtime: the minimum of 48 hours between shifts in the regular schedule can get reduced to 24.

CHANGES IN THE 12 HOUR SCHEDULE

13. Do you feel there are ways in which the shift schedule could be improved? If so, how?

Operators said that much time is devoted by some people to discussing this issue. They also said that the schedule is voted on once a year. At the last vote three different schedules were offered but the current one, which has already been in place for two years, won out.

Four out of 9 operators said that the best way to improve the schedule was to reduce the number of hours worked. They pointed out that the daytime workers at Ontario Hydro work 35 hours a week (with unpaid lunches and no requirement to be on call during lunch) but that shiftworkers, who spend a good portion of their "time off" recovering from time changes, work 40 hours.

Four operators said they found the requirement to make turnovers so frequently was difficult and they would prefer to work 4 midnights in a row which would reduce the number of turnovers. This could also result in increased time off for the turnover which 3 operators viewed as a desirable change. Only one operator said he would like to see 2 rather than 3 midnights in a row since 3 was too fatiguing. Operators were asked to estimate how many of their fellows would prefer 4 midnights in a row and how many would want this reduced to 2. Estimates for this varied widely.

One operator said he liked the schedule as it was and any changes that improved some aspects of it would make others worse. A number of operators were asked which feature of the current schedule they felt most strongly about retaining ; 4 felt the most important feature of the current schedule was 3 weekends out of 5. A number of operators mentioned the problem of starting the cycle (after 9 days off) with a day shift which tends to be busier ; all who commented on this agreed that starting the schedule on midnights (when one is used to getting up later anyway) would make it easier to get up to speed on plant changes.

14. How would you feel about reducing the number of night shifts worked in a row to 2 to prevent yourself from starting to adapt to nights?

Most operators who were asked this question felt negative about this idea. They pointed out that the third night was the easiest and that reducing the number of nights in a row would increase the number of turnovers, which they found difficult.

15. How would you feel about having more time off after the 3 midnights and less time off after the 2 day sequence to recover?

Of 4 operators who responded to this question directly, 2 agreed with the suggestion outright, 1 said he would like it but was sure this would result in a problem somewhere else in the schedule. One said he had no trouble getting off midnights and wanted to keep the longer time off (during which one was not recovering from a time change) after the 2 day shifts.

OVERTIME

16. How frequently are you called in unexpectedly (i.e. for overtime that is not planned)?

The answers to question 10 indicated that by far the most frequent reason for working overtime was to cover other people's vacations. Also some operators commented on the fact they they were reluctant to take sick leave and only did so if absolutely necessary, because they knew a fellow operator would have to be called in unexpectedly as a result. From these answers and other discussion it would appear that being called in unexpectedly is unusual.

17. How frequently do you trade shifts with someone else?

Of the 8 operators who were asked this question, 6 said this occurred very rarely, once per year or less; 2 operators said they never did this. One operator said trading shifts happened more frequently on the eight hour shift schedule. Another operator pointed out that because of the current shift schedule it was difficult to make a simple swap of shifts and often 3 operators had to be involved to organize it.

18. Is there ever pressure to work overtime when you would prefer not to?

The first few operators asked this question made it clear that there was definitely no pressure from supervisory personal to work overtime when operators

were reluctant to. Some operators mentioned that although there was no pressure from supervisory personal, there was peer pressure in the sense that if you were going to take vacation, you would have to cover for someone else.

In general, the answers to questions about overtime indicated that the problem had eased considerably over the last year with the acquisition of a fifth licensed operator for each unit. At both A and B plants first operators said they either worked very few shifts overtime or none at all.

BREAKS

19. Could you describe the type and length of breaks you usually take during the course of a 12 hour shift? Do the day and night shifts differ in this regard?

20. Do you feel the total length of breaks you are officially allowed is adequate? If not, what break schedule would be adequate?

Operators seemed satisfied with the current arrangement of break periods, particularly since the official schedule is by no means rigidly adhered to. It appears that operators have less freedom to take breaks during the day and sometimes skip them altogether when the unit is busy. On being questioned about general concerns related to shift work, none of the operators expressed concerns about the length or adequacy of breaks.

FATIGUE

21. Which shift do you find most difficult?

Of the 8 operators who were asked this question, 4 said they found the second midnight shift most difficult, 1, the first midnight shift and 3, the days following a short turnover.

22. During what time periods is it most difficult to remain alert?

23. What techniques do you use to remain alert?

Since these questions appeared later in the interview few operators were asked them directly. Discussion following other questions indicated that the most difficult period to remain alert was the early morning period. Some operators talked of the phenomenon of beginning to become more alert again about 6:30 am; other operators mentioned having extreme difficulty staying awake on the drive home.

In terms of techniques for staying awake the most common ones appeared to be coffee, conversation or taking a walk in the plant. Operators who had access to radios found listening to news broadcasts helped keep them alert. Several operators found the use of the exercise room resulted in greater alertness.

24. Do you ever find yourself or do you notice others nodding off briefly?

Of 9 operators 7 said they did find themselves, or noticed others nodding off briefly. The other 2 said people do get sleepy. Several operators emphasized that this do not mean people were sound asleep in the control room but rather that people were known to occasionally close their eyes for a few minutes.

25. Do you or others ever need to sleep during your meal break?

Responses to this question were mixed, some saying they had seen people sleep during their meal break and others saying they had never seen this.

26. There are a number of jobs where workers sleep under designated conditions while on duty. Is there any way work could be organized so that it would be possible for operators to take a nap during the night shift?

Of 8 operators asked this question 7 said yes that work could be organized so that a short nap would be possible while on duty. Several were very skeptical that management would ever allow this. The responses indicated that a quiet room where one could have a short nap in a chair for a specified period would be most beneficial.

ORGANIZATION OF SLEEP

27. How do you arrange your sleep at home when you work nights? when you shift from nights to days? when you shift from days to nights?

Several operators spoke of steps necessary to ensure they got a good sleep during the day; these included having their wives take children out for awhile and soundproofing the bedroom. The general strategy seemed to be to take sleep all in one main period rather than to sleep until around noon and then again later in the day as many 8 hour night shift workers do. The 12 hour shift does not seem to allow sleep to be broken in this way.

Several operators said their technique for shifting from nights to days involved disciplining themselves to get up after 3 hours sleep the morning after the last night shift. This resulted in them feeling lousy the entire day but allowed them to be sleepy enough to sleep that night. Some are not able to do this and find it difficult to sleep the first night after the end of midnights and they are sleepy during the first day shift. Some operators have not yet come up with a satisfactory sleep pattern.

EFFECTS ON HEALTH

Out of 6 operators asked this question, 3 said they didn't think 12 hour shifts had had any adverse effects on their health. One said yes, his resistance was down and a couple said that if you went into work not feeling well you would be in really bad shape by the end of the shift.

SECOND JOBS

29. Do you notice if there are more people with second jobs since the introduction of the 12 hour shifts?

Only a few operators were asked this question. Their response was that second jobs were rare and if people had them at all, they were self paced jobs such as farming or trades work. An increase in second jobs since the changeover had not been noticed.

EFFECTS OF LONG PERIODS OFF

30. After an absence of several days, or after a major change in plant status, do you experience any difficulty in getting up to speed on the plant status? What could improve this situation?

The operators asked this question said that it did take some time getting up to speed after a long absence. Some said that during the first few hours you were not completely sure of which equipment was in service or what condition everything was in. Getting up to date was made more difficult because the shift cycle begins on a Monday day shift which can be a busy time. Several operators agreed that starting the shift cycle on a midnight would improve this. Another operator said it would help if the outgoing operator was aware when the incoming operator had been away for a long stretch of time so that the former could be prepared to pass on more information during the turnover.

GENERAL COMMENTS

At the end of the interview operators were asked what changes could be made to improve their ability to cope with the 12 hour shift schedule.

Operators expressed a number of concerns: the need for more licensed first operators to cover for vacations, absences etc., the upcoming "locking up of supernumary days" which would mean less time when vacations could be taken without requiring coverage, the difficulty of keeping up with the required reading during the day shift when one was either constantly interrupted, or on night shift when reading and comprehending new material was difficult. Operators felt that work should be deliberately organized so that complex jobs were not carried out at night and particularly not towards the end of the night shift when people were at a low point. It was felt that the fact of a physiological low point should be recognized in contrast to the current policy of 24 hour operation.

A number of operators expressed the feeling that the shiftworkers were treated as "second-class " workers and cited numerous examples: the lack of appreciation by day time personnel that a significant portion of their " time off" was compromised by fatigue due to shift changes adjustments; the lack of extra sick leave days in recognition that shift workers are statistically more likely to get sick than administrative staff who work days, simply because of the continual adjustments to time changes, and a number of petty irritants such as difficulty obtaining one's paycheque at nights on a holiday, closure of gates at night which results in a longer drive to the plant, and no early layoff for shiftworkers who could take it at Christmas time.

2. RESPONSES OF CONTROL ROOM SUPERVISORS

PREFERENCE WITH RESPECT TO SCHEDULES

1. Which do you prefer, the 12 hour shift schedule, or the old 8 hour shift schedule? Why?

3. Has your attitude towards 12 hour shifts changed since they were introduced? In what way?

4. What percent of first and second operators would you estimate would prefer to go back to 8 hour shifts?

Of the 6 supervisory personnel questioned, 4 had worked 8's and so had some basis for comparison with 12's. Of these 4, 2 preferred 8 hour shifts and 2 were ambivalent. Three of the 4 felt less positive about 12's since their introduction. Three people gave estimates of the number of first operators who would want to go back to 8's as 35%, and >50%(2). Second operators were judged to be less likely to want to go back to 8's.

INDIVIDUAL DIFFERENCES AND SHIFT WORK

2. I understand there are some operators who prefer 12 hour shifts and some who dislike them. What characteristics, in your opinion, distinguish between these two groups?

Of the 5 people who were asked this question, 4 identified the primary factor as the level of responsibility. In general the feeling was that the greater the level of responsibility, the less people liked the 12 hour shifts. For supervisors and for first operators 12 hours was felt to require too much mental energy during outages. For first operators during normal operation, 12 hours was felt to be long and boring. It was felt that field personnel preferred the 12's because their work was more self paced, their work was more varied and they could physically move around more during the shift. People who were younger or who placed a high value on reduced trips to work were identified as preferring 12's.

ORGANIZATION OF WORK

5. Do you organize your work differently on the 12 hour schedule compared to the 8 hour schedule? If so, how?

6. Do the day and night shifts differ in the nature of the tasks that are performed?

What periods of the day (night) consist mainly of monitoring?

Day and night shifts were said to differ in level of busyness in 3 main ways: first, during the day 'G' crew, an extra maintenance crew were on duty and this increased the workload for the operators and supervisors; second, a greater proportion of the night shift was occupied mainly with monitoring, 75 - 85% vs. 50-65%; and third, one supervisor commented that managers try not to hand out complex jobs after 4:00am because they feel there are likely to be more errors made.

OFFICIAL SCHEDULE VS. PRACTICE

7. How often does the total turnover time for a shift exceed half an hour?

Of the 2 supervisors asked this question, both said it occurred very rarely.

8. How often do you work longer than 12 hours on a shift?

9. What is the longest period you have ever worked continuously? Under what circumstances did this occur?

Working longer than 12 hours appeared to be unusual. One supervisor said that he was only aware of people staying on shift for 16 hours on 5 occasions in the last year. Another supervisor said that working 16 hours happens to at least one SS every 2 months in order that all SS's can meet at the same time. One supervisor commented that 16 hour shifts were worked more frequently on the 8 hour schedule when people worked a double shift, than is the case on 12's. No one was aware of shifts longer than 16 hours. One supervisor commented that though people on regular crews did not work more than 16 hours, other technical personnel from head office sometimes worked as much as 20 hours straight, and construction crews worked 12 hours a day for many days running.

10. What is the most frequent reason for working longer hours?

Most of the comments on overtime related to the first operators being supervised rather than the supervisors themselves. The main reason for first operators working overtime appeared to be staff shortages due to vacations. Of the 6 supervisors 4 talked about the need for 6 licensed operators per shift rather than the 4 currently required by AECB. One supervisor felt manpower planning had been poor, in that such a long time elapsed between groups of first operators being licensed. One supervisor suggested that with 6 licensed firsts per shift, 2 could be put on simulator training required for requalification. During this regular requalification the operators could have a 'normal' life (i.e. day shifts) for 3 months of the year.

One supervisor commented at length on the difficult licensing program now in place. He felt that for first operators it meant making a supreme sacrifice of time for 2 to 3 years, and that it was a much more difficult to obtain a licence than to acquire a university degree. The reason for the greater difficulty was the large amount of memory work required in order to give the exact answers required on the exams. He felt this process made it difficult for operators to move from one station to another (and therefore it would be difficult for Hydro to easily move first operators around as needed) because once operators had been licensed for one station they were unwilling to make the same sacrifice to obtain a licence for another station.

11. What is the most number of dayshifts you have worked in a row? Night shifts?

Of the 5 who responded to this question, 3 said they had worked at most 5 nightshifts, and 2 said at most 4 nightshifts. Five nightshifts in a row on the 12 hour shift appeared to be the most anyone had heard of. One supervisor com-

mented that he had worked 5 nights in a row just once and refused to ever do it again. Another supervisor commented that on the 8 hour schedule people worked many more shifts in a row than this.

12. Have you ever had less than 48 hours off between the end of a night shift and the start of a day shift? If yes, under what circumstances? How frequently has this occurred?

Of the 5 people who were asked this question all had experienced having less than 48 hours off between the end of a night shift and the start of a day shift. Two supervisors said that first operators did this fairly frequently and that it was difficult to arrange coverage without breaking either the 60 hour per week limit or having less than 48 hours off between the end of a night shift and the start of a day shift. The main reason recovery time is reduced to 24 hours is that when coverage is needed for a night shift, the operator called is generally one who has just finished two or three nights and is somewhat adapted to nights. Since the schedule allows only 48 hours after most sequences of night shifts, adding an additional night shift results in less than 48 hours off.

13. Do you feel there are ways in which the shift schedule could be improved?

One supervisor said he liked the schedule as it was. Two said the schedule was voted on every year and they would certainly not want to see any more than 3 midnights in a row. One said he would like to see more midnights in a row because he found the changeovers difficult.

14. How would you feel about reducing the number of night shifts worked in a row to 2 to prevent yourself from starting to adapt to nights?

Two supervisors didn't feel this would help much since the third night is the easiest.

15. How would you feel about having more time off after the 3 night sequence but less time off after the 2 day sequence to balance this?

Of the 3 supervisors who were asked this question, all said they would like to see this, but one felt any change meant they would suffer somewhere else.

OVERTIME

16. How frequently are you called in unexpectedly (i.e. for overtime that is not planned)?

Unplanned overtime for supervisors appeared to be a very rare occurrence, a few times a year or less.

17. How frequently do you trade shifts with someone else?

Trading shifts appeared to be relatively infrequent, though one supervisor said 2 people did this frequently. Though mutuals are not recorded the supervisor's permission must be obtained to ensure the 60 hour rule is not broken.

18. Is there ever pressure to work overtime when you would prefer not to?

Since overtime for supervisors appeared to be infrequent this question was not asked of them.

BREAKS

19. Could you describe the type and length of breaks you usually take during the course of a 12 hour shift? Do the day and night shifts differ in this regard?

20. Do you feel the total length of breaks you are officially allowed is adequate? If not, what break schedule would be adequate?

In general the responses to these questions indicated supervisors were not rigid in applying rules about official breaks and the number of breaks people took varied a great deal from one individual to another. One supervisor estimated that half the operators went out a couple of times a shift for anywhere from 10 to 30 minutes and that the typical lunch lasted 45 minutes. One supervisor said he encouraged first operators to take a break from the control room by going out to the field, but said some firsts were reluctant to do this.

FATIGUE

21. Please mark on this schedule which shift you find most difficult. Why do you find this(these) shifts difficult?

Answers to these questions varied a good deal. Three supervisors mentioned the problem of fatigue due to quick turnovers, one found 3 shifts in a row, day or night, fatiguing and one found days in general most difficult due to having to get up at 6:00 am and having no time to do anything upon returning home other than sleep. Another supervisor commented that the first day of the 35 day shift cycle was very frustrating because of being out of touch with the plant after a period of days off.

22. During what time periods is it most difficult to remain alert?

23. What techniques do you use to remain alert?

Due to time constraints only 2 of the 6 supervisors were asked these questions. Both emphasized the need for a very disciplined approach to obtaining sufficient sleep. One commented that the more responsibility one had, the more disciplined one was required to be. In his opinion, first operators were on the whole very careful. Another supervisor commented that he felt about one third of the staff (operators? maintenance?) were undisciplined in obtaining sleep and didn't, for example, prepare for nights properly. Two supervisors commented that it was younger people with a busy social life who tended to be undisciplined about sleep.

24. Do you ever find yourself or do you notice others nodding off briefly?

25. Do you or others ever need to sleep during your meal break?

All of the supervisors had noticed control room staff nodding off briefly from time to time. One supervisor commented that this happened on 8's as well as

12's, that it happened to some individuals more than others, and that it happened to everyone who works shift from time to time. Estimates of the frequency of this occurring were consistent, varying from once or twice a cycle (35 days) to rarely. Supervisors responded to sleepy staff in various ways, engaging them in conversation, encouraging them to get a coffee or go for a walk. In reference to this latter suggestion, it was noted that taking a walk was frowned on by management.

26. There are a number of jobs where workers sleep under designated conditions while on duty. Is there any way work could be organized so that it would be possible for operators to take a nap during the night shift?

Of the 4 supervisors who were asked about this, 1 was against the idea and thought a field tour would be better, 1 was uncertain and 2 said having a brief nap would help.

27. How do you arrange your sleep at home when you work nights? when you shift from nights to days?

Of the 3 supervisors who responded to this question, 1 said he was always experimenting, trying to find a satisfactory sleep pattern, 1 used to get up after 3 hours sleep after the last night shift but now waits until 2:30 pm to go to sleep, and the third takes one long main sleep period after the end of the night shifts. (Both of the latter two patterns would likely make it difficult to sleep the night which preceded the first day shift).

EFFECTS ON HEALTH

28. Do you feel that working longer shifts has had any adverse effects on your health?

Only 3 supervisors were asked about this. They said it had. Two commented on the greater difficulty people have as they get older of rebounding. One said his doctor sees a lot of health problems he feels are due to the longer shifts, but people won't admit this is the reason. One said recovery after illness takes longer on 12's.

SECOND JOBS

29. Do you notice if there are more people with second jobs since the introduction of the 12 hour shifts?

Answers to this question varied a lot. One supervisor said lots of people have second jobs (of the self paced variety), another said he didn't know of anyone with a second job and the third said that personnel at the hydraulic stations who worked 8 hour shifts were more likely to have second jobs.

EFFECTS OF LONG PERIODS OF TIME OFF

30. After an absence of several days, or after a major change in plant status, do you experience any difficulty in getting up to speed on the plant status? What could improve this situation?

Two supervisors said that the first day back after a 10 day stretch away was very frustrating. One of these said it took all day to figure out the plant status. Another supervisor said that to improve this situation people should come in earlier.

GENERAL COMMENTS

The most frequent comment made about ways to improve the situation with 12 hour shiftworking was to increase the number of licences per shift to 6. Five of the 6 supervisors mentioned this. One said you can't really be serious about refresher training otherwise. Two supervisors suggested a routine whereby each licensed operator would take off a period of 3 months per year where all training was done. Another supervisor pointed out that all other nuclear plants have 6 licences per shift. The sixth supervisor merely commented that there was a great deal of reading material for the first operators to keep up with.

On the subject of plant safety and 12 hour shifts, 3 supervisors commented that complicated jobs should be deferred to the day shift if at all possible; at the very least the early morning hours should be avoided. One of these supervisors commented that the ability to diagnose a situation or think creatively is much slower at night. He also said that experience teaches you that upsets occur at the end of a shift. Two other supervisors said that the problem wasn't 8's versus 12's but rather working during the early morning hours. Another supervisor said that most errors resulted from lack of familiarity or a long time lapse since the procedure had been carried out before, rather than being associated with the time of day the procedure was carried out.

Two supervisors said that the unique problems of shiftworkers are not recognized by management. One supervisor said he would like to have access to advice from an acknowledged and non-Ontario Hydro expert on the best ways of coping with shiftwork.

One supervisor expressed concern about those operators who worked a lot of overtime. He said about 25% do most of the overtime and about 10% never do any at all. He felt those who did a lot of overtime should be monitored carefully.

Two supervisors said that reducing the hours to 35 per week would help reduce fatigue.

5. RESPONSES OF MAINTENANCE PERSONNEL

PREFERENCE WITH RESPECT TO SCHEDULES

1. Which do you prefer, the 12 hour shift schedule, or the old 8 hour shift schedule? Why?

2. Has your attitude towards 12 hour shifts changed since they were introduced?

3. What percent of the maintenance mechanics (control technicians, supervisors) would you estimate would prefer to go back to 8 hour shifts?

Out of 6 control technicians, 7 maintenance mechanics and 6 supervisory personnel interviewed, all but 2 preferred 12 hour shifts. The main reason for this preference was the greater number of days off. Many people also commented on the reduced time spent commuting to and from work and the fewer trips to and from work. Three people said that they found midnights easier on 12's than on 8's. Three people said it was easier for their families on 12's. Three people said that more work got done on 12's than on 8's because a smaller percentage of the time worked was devoted to obtaining work protection, setting up the job (which could involve a great deal of time, for example, with machining) and cleaning up. Also on 12's it was more likely that you would be able to finish a job you had started, leading to a greater degree of job satisfaction.

Those who liked the 12's expressed much dissatisfaction with the old 8 hour schedule. One person said on this schedule it was possible to work 20 out of 25 days. Another said that the stretch of midnights followed by supernumaries was essentially 10 days straight work because the single day off was spent recovering from the time change. Another said that on the 8's the schedule was always changing, while on the 12's it had remained the same. Another commented that for the whole week of afternoon shifts he never saw his school age children.

One of the individuals who didn't like 12's was initially very much in favour but finds now that he feels dragged out all the time and his family dislikes them. He said that 12 hour shifts are difficult for people with school age children because they don't see the children at all when they work day shifts and the children have to be kept quiet on the weekends when the midnight shifts are worked. He commented that shift work is for young people and he is attempting to get onto the daytime G maintenance crew. The other individual who didn't like 12's found that over the 35 day cycle he became more and more tired. If he didn't have the supernumary period off he found it difficult to recover before starting back on the next 35 day cycle.

Amongst the personal interviewed estimates of the percent of their colleagues who would want to return to 8 hour shifts was consistently low, ranging from 0 to 25% for those maintenance mechanics and control technicians who liked the 12 hour shift. Amongst the supervisors estimates ranged from 0 to 40% for those who liked 12 hour shifts. The individuals who did not like 12 hour shifts gave higher estimates than their fellows of the percent who would want to return to 8 hour shifts. A number of people pointed out that those who found the 12 hour shifts, or shift work in general, hard to cope with, had the option of getting on the 8 hour shift day crew. However, opinion varied about how easy it was to get on to

G crew. One person said G crew was mainly for older people or people with health problems. One person pointed out that at BHWP the majority of maintenance people are on days which makes it easier there to get off shift. One control technician commented that since their skills were specialized it was difficult to have a greater proportion of control technicians working on days. This had apparently been attempted at Bruce A NGD but it had not worked.

ORGANIZATION OF WORK

SUPERVISORS ONLY

4. Do you organize the work of your staff differently on the 12 hour schedule compared to the 8 hour schedule? If so, how?

Supervisors said that they did not organize the work any differently on 12's as compared to 8's.

5. Do the day and night shifts differ in the nature of the tasks that are performed? For example, do more difficult jobs tend to be done during the day? Would you say jobs done on the night shift take longer to complete or result in more errors?

When asked about the assignment of work at night, particularly around 4:00 am, 3 supervisors said they were careful about what work was assigned at this time because people were tired. One said the potential for error was greater on night shift. One said not as much got done on night shift. Another said he didn't notice any difference in work quality or pace at night.

Amongst the mechanical maintainers and control technicians interviewed, 3 said that where possible more complex jobs should be assigned during the day instead of during the night, because people had more difficulty being alert at night. Three said assignment of jobs actually was different at night and that difficult jobs were avoided in the early morning hours. Three said that assignment of jobs couldn't be different for the day and night shifts.

6. Are there periods of the day (night) shift in which there is very little to do?

Three of the supervisors said there was always work to do. One supervisor said that work goes in cycles, sometimes busy and sometimes not, but weekends were difficult because there was not enough to do.

OFFICIAL SCHEDULE VS. PRACTICE

8. How often do you work longer than 12 hours on a shift?

9. What is the longest period you have ever worked continuously? Under what circumstances did this occur?

Working longer than 12 hours appeared to be a very rare occurrence. It might happen where a job was within an hour of being finished but this was unusual.

10. What is the most frequent reason for working overtime?

The main reason for working overtime was given as plant problems rather than staff shortages.

11a. What is the most number of dayshifts you have worked in a row? Night shifts?

Four individuals had worked as many as 4 day shifts in a row, 2 had worked 5 day shifts in a row. Four individuals had worked 4 night shifts in a row and one had worked 5 night shifts in a row.

One individual noted that while he had worked for the construction company on the site (rather than directly for Hydro, he had worked 14 consecutive 12 hour shifts.).

11.b How frequently do you work overtime?

It appeared that it was unusual to work overtime on a steady basis. Overtime was mainly worked during shutdowns for a concentrated period of time. One person reported working for a period of 3.5 weeks for 10 hours a day, 6pm to 5am, 6 nights a week on a job which in his opinion involved some fairly dangerous work. Another person reported working an extra 20 hours a week for a period of 4 or 5 weeks. Half of the people asked this question either never or rarely worked overtime.

12. Have you ever had less than 48 hours off between the end of a night shift and the start of a day shift? If yes, under what circumstances? How frequently has this occurred?

About half of people asked this question had experienced this situation but it appeared to occur very infrequently.

13. Do you feel there are ways in which the shift schedule could be improved? If so, how?

Of 12 people asked this question, 4 said the best way to improve the schedule would be to eliminate the supernumary days, resulting in a 35 hour work week. One said the union had attempted to negotiate this several times and had offered a wage freeze, but the idea was rejected. Three people said there was no way to improve the schedule, 2 said they found the short turnarounds after midnights difficult. One said that only 5 or 6 mechanics were needed on night shifts but they had 12. Another commented that the best way to handle work during outages was to work 12 hour day shifts continuously, rather than rotate shifts. Another said no one liked working supernumaries since they involve 5 days in a row and often there is no meaningful work planned, just make-work.

14. How would you feel about reducing the number of night shifts worked in a row to 2 to prevent yourself from starting to adapt to nights?

Of the 13 people who were asked this question, 6 were positive, 4 negative and 3 ambivalent. Two of these latter 3 were worried about negative impacts on other aspects of the schedule, like losing a week-end.

15. How would you feel about having more time off after the 3 night sequence but less time off after the 2 day sequence to balance this? Why?

Of 13 people asked this question, 6 were positive about the idea, 3 were negative and the rest were ambivalent. Several people referred to a philosophy of some workers, that it was better to recover on Hydro's time rather than one's own.

OVERTIME

16. How frequently are you called in unexpectedly? (i.e. for overtime that is not planned)

Because answers to earlier questions indicated people did not work much overtime except for short periods during scheduled outages, few people were asked this question. The 4 who were asked indicated this was a very unusual occurrence.

17. How frequently do you trade shifts with someone else?

The 14 people asked this question either said they did it very rarely or never.

18. Is there ever pressure to work overtime when you would prefer not to?

Of the 5 people asked this question, 3 said they never felt any pressure and 2 said the pressure they felt came from themselves rather than the person asking them.

BREAKS

19. Could you describe the type and length of breaks you usually take during the course of a 12 hour shift? Do the day and night shifts differ in this regard?

Breaks taken appeared to be dependent to some degree on the demands of the work being carried out. Respondents did not express any dissatisfaction with the number and length of breaks taken and seemed to feel they had a sufficient control over the timing and length of breaks.

Fatigue

20. Please mark on this schedule which shift you find most difficult. If there are several of equal difficulty please mark them all. Why do you find this(these) shift(s) difficult?

The first night shift was identified as the most fatiguing by 7 respondents, the second night shift by 5 respondents and the first day shift after nights by 3 respondents. The difficulty mentioned most frequently (6 times) was that of obtaining adequate sleep during the day prior to the first night shift. The problem appeared not to be taking the time to do this but rather being able to fall asleep and stay asleep for long enough.

21. During what time periods is it most difficult to remain alert?

The number of people reporting various time periods as fatiguing are shown below:

a.m.	
2-3	1
3-4	2
4-5	5
5-6	9
6-7	7
7-8	3
8-9	1

One person reported the most fatiguing time period as being 2-3 pm.

22. Do you ever find yourself or do you notice others nodding off briefly? If yes, how often?

Falling asleep outside of the meal or coffee breaks appeared to be unusual though 2 people commented that this might happen when someone was working as part of a pair and had nothing to do until his partner finished what he was working on.

23. Do you or others ever need to sleep during your meal break? How often?

Three people said they themselves slept on meal breaks, usually the second one around 4:00 am. Nine respondents said that others slept on meal breaks. Five people gave estimates of the number of people who had a nap during the night shift meal break. These estimates were: 10%, 33 - 50%, 30%, 30% and 50%. Four respondents commented that in other industrial situations the night shift is seen as being there for emergencies only and people sleep unless they are called. These situations included Dofasco, the oil industry, Inco and a nuclear plant in Korea. Several people who did not take naps themselves said they did not do so because they felt groggy after they woke up. People who did take naps said they felt refreshed when they woke up.

Organization of Sleep

24. How do you arrange your sleep at home when you work nights? when you shift from nights to days? when you shift from days to nights?

In discussions of sleep patterns, 11 respondents said they found it necessary to cut short their sleep after the last night shift, and get up before they had had adequate rest, if they were going to be able to sleep well that night. Eight respondents said they had more trouble sleeping the second night (just prior to returning to day shift) than during the first night (the first night following a sequence of night shifts).

Two respondents said they used sleeping pills and estimated that large numbers of the people on shift did so.

Effects on Health

25. Do you feel that working longer shifts has had any adverse effects on your health?

Only 2 respondents felt that longer shifts had any effect on their health. However, 3 of those who said it had no effect on their health made comments that they were generally tired, had to be very careful about getting adequate sleep and once they were off shift for a month noticed how much better they felt although while on shift they had not noticed any problems.

Second Jobs

26. What % of other mechanics (control technicians) have second jobs?

The estimates given of those having second jobs were very low, with 10-15% being the highest estimate.

Effects of Long Periods of Time Off

27. After an absence of several days, or after a major change in plant status, do you experience any difficulty in getting up to speed on the plant status? What could improve this situation?

Getting up to speed on plant status did not appear to be a problem for most people, although one supervisor noted that he had to come in one hour early when he had been absent for a few days.

General Comments

Comments were made on four issues in particular: work planning, 24 hour operation policy, lack of management recognition of the difficulty of working shifts, requirement for more information on adjusting to shift work and need for rotation on and off shifts.

Five respondents commented on the need for better work planning. In particular there was resentment of "make work" on supernumaries and on night shift. Five respondents wondered why Ontario Hydro went with a 24 hour operation policy when other industries used a skeleton maintenance crew at night for emergencies only. Two other respondents said official policy should allow people to sleep at night when there was no work to do, and 2 others said a comfortable place should be provided for people to take short naps. Three respondents said there was no recognition by management that working shifts was harder than working days. Related to this 4 other respondents said the shift premium was poor. Three respondents said they would like to see a 35 hour work week. Four respondents said more information about how to best adjust to shift work would be appreciated. Five respondents said that people should be rotated on and off shift work. One commented that since they were all hired on the understanding they would be working shift, it wasn't fair that some people were able to then get permanent day positions.